Domestic electricity consumption: **The influence of household fluidity on domestic electricity consumption.**

LYNCH, DAVID MICHAEL 2014.

Abstract

The influence of household fluidity on domestic electricity consumption:

UK households today are transient, subject to change and are therefore 'fluid' in nature, prompting the need for research into the dynamics of household fluidity and its influence upon domestic electricity consumption.

Fluidity may be planned or brought about by unexpected events. Fluidity can be the result of divorce or separation, birth(s), illness, death(s), amongst other changing circumstances. Fluid households and their occupants often find themselves adapting to change which is reflected in alterations to their electricity consumption; a reactive by-product of such change to meet the demands of revised living arrangements or technical infrastructure within the household.

The research adopts a multi-method approach capturing qualitative and quantitative data from participating households during 2012-2013 and is designed to answer four central questions: What are the characteristics of fluid households? What impact does household fluidity have upon domestic electricity consumption? Does household fluidity restrict or enable a household to be flexible in its electricity consumption? What are the implications of fluid households for future domestic electricity network planning and management?

Empirical data generated from interviews and electricity consumption are presented in the form of eight case studies. Each case study provides insight into the nature and extent of fluidity and transitional flux that can exist within UK households. The findings contribute to an improved understanding of the implications of household fluidity upon domestic electricity consumption, sustainability of low carbon technologies, and their implications for network planning and management.

This research was undertaken as part of a broader Low Carbon Network Fund (LCNF) programme entitled the Customer Led Network Revolution: www.networkrevolution.co.uk

The influence of household fluidity on domestic electricity consumption:

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Year: 2014

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Abbreviations

CLNR	Customer led network revolution
DECC	Department of Energy & Climate Change
DNO	Distribution network operator
IHD	In home display
kWh	Kilowatt hour
LCNF	Low carbon network fund
PV	Photovoltaic
TC	Test cell
ToU	Time of use tariff

Statement of copyright

Acknowledgments

I would like to express my gratitude to Northern Powergrid for funding my Masters by Research in Anthropology. I would also like to thank my employer National Energy Action (NEA) providing the support and flexibility to undertake this research.

I am grateful for the support of my two supervisors, Dr Stephen Lyon and in particular Dr Sandra Bell who continued to push me along the way. I am also thankful to Jamie Lawson, Dr Gareth Powells, Jenny Saunders, Peter Smith and Nina Dunlavy for their advice and guidance provided.

Without the co-operation of my sample of householders across the Yorkshire and Humber this research would not have been possible, I am extremely grateful to those who took part.
Finally, I would like to thank my family and my partner Claire for their encouragement and putting up with me over the last two years.

Chapter 1: Introduction

Imagine a static bricks and mortar household; lift its roof and peer inside. The lives of those within the household are subject to change, what residents consider the 'status quo' is merely a temporal state. In reality, the lives of those in residence are subject to change over time. Such change can be erratic and can arise due to positive experiences, economic success, a windfall, births, marriage or negative experiences, a change in financial circumstance, divorce, illness, disability or death. Although households on the outside may appear static in their built form, the lives of those contained within the households are subjected to change, they are 'fluid'. The nature of such 'fluidity' and the impact it has upon domestic electricity consumption forms the core focus of this thesis.

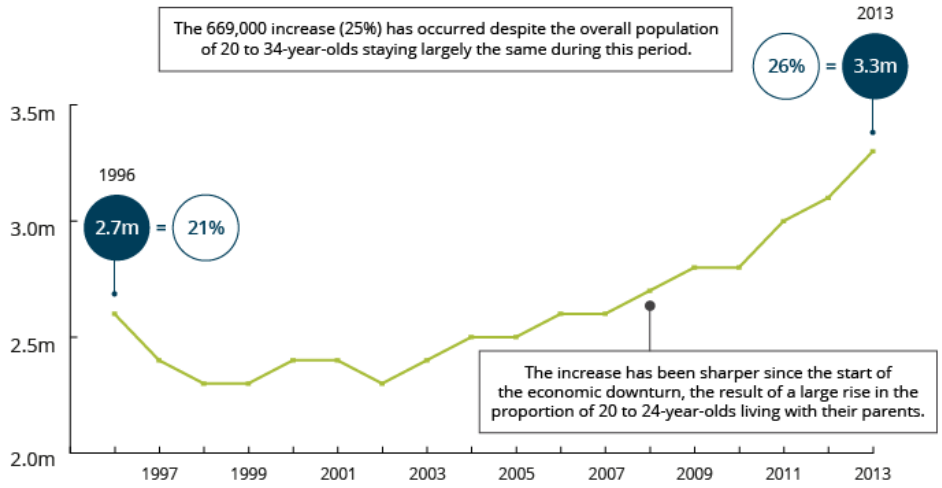
Academic contributions investigating drivers of domestic energy behaviour are expansive but are yet to explore household 'fluidity' and the impact it has upon domestic electricity consumption. Household fluidity carries with it implications not previously explored in the context of domestic electricity consumption. As this thesis demonstrates, fluidity impacts upon the timings of electricity related practices (timings and thresholds) it can close down or reopen areas within the home (hubs and environments) and be a source of daily debate (conflict and contestation) around electricity consumption.

Households today often find they have to respond to changing circumstances which have a direct impact upon the shape and nature of their electricity composition. Since the 1950s profound demographic changes have taken place all over the world not just here in the UK. Living arrangements such as never marrying, cohabitation and single-mother households have gained importance (Keilman 1998, Hall 1986, also Swartsz 1998). Fertility rates have decreased whilst life expectancy and divorce rates have increased. Average household size has become smaller and the number of households has increased. These trends have been attributed to industrialisation and modernisation, as well as changing attitudes towards traditional family values, gender roles, marriage and parenthood (Keilman 1988).

These social trends mean across many age groups individual circumstances are increasingly subject to change or fluidity. People find they have to adapt and this often means a change in living arrangements. As this research illustrates, households and their occupants often find themselves adapting to change; electricity consumption must also adapt to meet the demands of revised living arrangements as well as changes in technical infrastructure.

Over the last ten years spiralling property prices and a collapse of the labour market have forced many young people to retain their living arrangements within their parent's home. In some instances children are returning to their parental home giving rise to a trend known as 'Boomerang Children.' Data from the Office of National Statistics (ONS) illustrated in figure 1 (below) show that while in 1997 one in four men and one in seven women aged 20-34 lived at home, by 2013 over 3 million people aged 20-34 were living with their parents; a 25% increase on the number (2.7m) in 1996.

Figure 1.0: Young adults aged 20-34 living with parents in the UK, 1996-2013 (ONS 2013)



Another generation known as the 'Sandwich Generation' has also emerged; again somewhat due to social and economic conditions. Those in this generation are typically in their 50s and 60s and find themselves sandwiched between financing their children's education and care whilst also caring for their elderly parent(s) who may also be living in their home or an annexe adjoined to the family home.

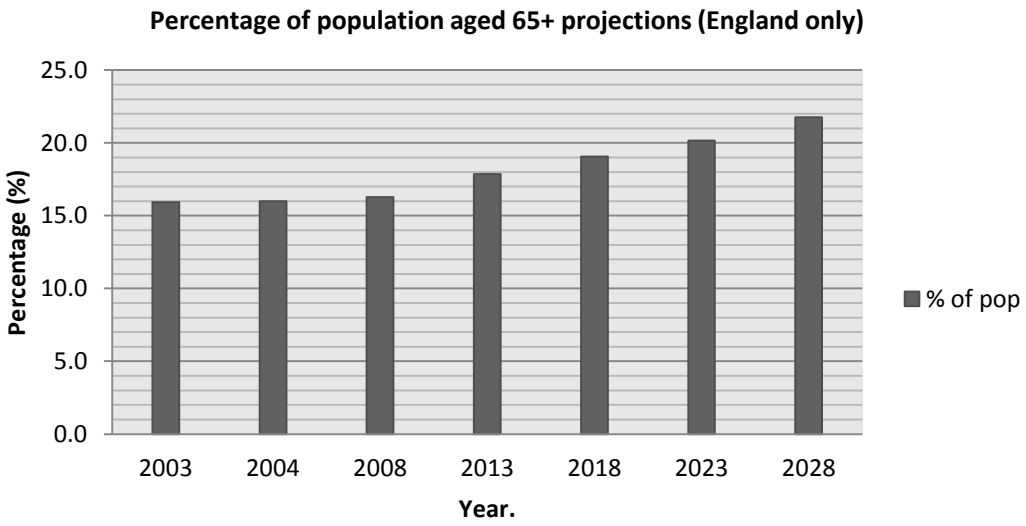
Statistics from the Journal of Financial Service Professionals illustrate that at the beginning of the 20th century between 4% and 7% of people in their sixties had at least one parent still living. Today, that figure is nearly 50%. People in their sixties who end up caring for an ageing parent often feel they are living the reality of what they may experience emotionally, physically and financially as they age.

As recently as 1990, only 25% of young adults between the ages of 18 and 24 lived with their parents. By 2000, the number had grown to 52%—and it's still rising, putting more older adults into the sandwich generation--caring for ageing parents and adult children. What's more, this sandwich generation is likely

to increase going forward as the elderly population of the UK is growing in size and ageing. Statistics from UK National Statistics[1] illustrate over the period 1985-2010 the number of people aged 65 and over in the UK increased by 20 per cent to 10.3 million; in 2010, 17 per cent of the population were aged 65 and over. The number of people aged 85 and over more than doubled over the same period to 1.4 million and the percentage aged under 16 fell from 21 per cent to 19 per cent. Population ageing will continue for the next few decades. By 2035 the number of people aged 85 and over is projected to be almost 2.5 times larger than in 2010, reaching 3.5 million and accounting for 5 per cent of the total population.

The population aged 65 and over is expected to account for 23 per cent of the total population in 2035, while the proportion of the population aged between 16 and 64 is due to fall from 65 per cent to 59 per cent.

Figure 1.1: Percentage of population aged 65+ projections – (England only) ONS 2013.



Such social trends and statistics are not just important for energy network planning; they also carry implications for key policy areas including health, social care, the ageing of the workforce and pensions, housing and transport.

[1] http://www.statistics.gov.uk/hub/population/ageing/older-people

The thesis begins by reviewing literature to examine some of the challenges faced by anthropologists and other social science disciplines when distinguishing between concepts of family, kinship and households. We then reflect upon societal and political trends taking place since the 1950s which have changed the dynamics of such concepts and reflect how the field of anthropology has responded. Once we have determined which concept is of most use as a unit of study we begin to evidence how households have become more fluid in nature, defining some of the societal trends and anthropological contributions.

In chapter three the focus then shifts to literature defining the key determinants of domestic energy behaviour. Chapter four defines the methodological approach adopted to collect both qualitative and quantitative data. A discussion of the challenges faced when conducting the research and its limitations is also presented. Chapter five presents the qualitative and quantitative results emerging from the fieldwork and energy consumption metrics.

The analysis of these findings is then presented in chapter six incorporating a thematic framework and evidence from the wider CLNR study to validate the analysis of eight case studies before final conclusions are made in chapter seven.

Chapter 2: Defining households, kinship and family

In the domestic setting, electricity consumption is often referred (Owen and Ward 2010, Hargreaves et al., 2009.) to as 'household' consumption. This in itself creates problems as it is the dynamic organisation operating within the household; often referred to as the 'family' which drives electricity consumption.

Contributions within the fields of anthropology and sociology offer unique perspectives helping to understand how kinship, households and families are constructed and function daily. As a starting point this chapter begins by exploring difficulties faced by anthropologists in conceptualising and compartmentalising distinctions between household, family and kinship. The historical context of this problem is presented before focusing on kinship, household and family forms since the early 1950s through the post-industrial era in Britain. The timescale chosen here is important in shaping the scope of this thesis. This period correlates with the opening up of 'mass market' sales of domestic electricity appliances (Beynon et al., 2003:9). Post-industrial Britain gave rise to diversity and fluidity in household structures, much of which has been the focus of sociological and anthropological studies (Back and Beck-Gernsheim 2003, Giddens 1998, Stacey 1996, Townsend 1957, Parsons, 1956) and such contributions shape our contemporary understanding of household forms and structures.

Finally, I illustrate contemporary examples of fluid households as I begin to consider how fluidity shapes relationships, gender roles, domestic routines and practices in relation to electricity consumption. The focus in this section is not centred on domestic electricity consumption, but identifies cultural interpretations from anthropologists and sociologists on the notion of family, kinship and household in order to clarify issues surrounding the use of the household as a unit of study.

2.1 Anthropological perspectives of household, family and kinship

Anthropologists as well as other social scientists have found themselves attempting to keep up with the social change to which studies of family, household and kinship had to respond. Anthropology has responded by discussing households, family cultures, forms and functions and how they have been influenced by a backdrop of shifting social and demographic trends. Yet, in comparison to sociologically-based studies of household, family and kinship, anthropology is not as prominent given that shifting social and demographic trends in western countries have for the most part been attended to by

sociologists with anthropologists firmly focused on the behavioural and cultural underpinnings of such change.

Wilk (1991) conducted a review of three ethnographic studies of family, household and kinship and criticised them for avoiding what he referred to as, 'a central issue, "what is a household?"' goes on to question: How do individual interests get balanced with those of the group? How are decisions made? How is authority realised? Why do people stay why do they leave? How do members negotiate rights and duties? (Wilk 1991:10)

In what follows I attempt to address Wilk's questions.

2.2 Distinctions between 'Families' and 'Household'

S.J. Yanagisako (2001) provides a useful discussion on the challenges faced by anthropologists in defining the boundaries between household, family and kinship claiming that anthropologists often use the term household 'loosely' to refer to a residential group; 'they distinguish the household from the family by defining the former as a residential unit and the latter as a kinship unit.' (2001:6930)

This distinction has shaped anthropological studies of households as well as families, kinship and domestic groups. An earlier contribution offered by Keesing (1958) identifies the boundaries for separating 'families' and 'kinship' lie in the broader claim that kinship and locality are two distinct principles of organisation. Yanagisako (2001) points out, 'these claims derive from the discipline's focus in the nineteenth and early twentieth centuries as to how social groups were organised' (2001:6930). Reviewing the literature around kinship during this period and what it meant to anthropologists reveals a sense of kinship being strongly related to 'genetic connection' and 'biological reproduction.' Yanagisako (2001) believes these two characteristics are 'politically important' as kinship is used to qualify individuals to become members of a group or clan. 'The literature and language around kinship during the early twentieth century detaches kinship from being tied to spatial connections or residential units for example, hamlets or villages' (2001:6938).

As anthropologists expanded their range of ethnographic research to include peasant communities, the notion of kinship was adapted over time. Anthropologists drew on the distinction between 'kinship' and 'locality' to differentiate 'family' from the 'household.' The family as a corporate kin group was distinguished from the household as a collection of kin who share a common residence. D.R. Bender

(1967) describes the boundaries between family and household became clear when defining rights to property or land:

> The corporate character of the peasant family was viewed as rooted in its jural rights to the property; usually land, which its members 'family' or 'non-family' held in common. 'Family' members supposedly retained these rights regardless of whether they were members of the same household. In this context 'family' and 'household', are both 'logically distinct' and 'empirically different.' (Bender 1967:493)

Defining differences between households fuelled comparative studies of households by anthropologists as well as historians, sociologists and demographers, most of which attached the term 'household' to groups of people sharing both a common living space and activities often defined as 'domestic.' Activities may relate to food production and consumption or to reproduction, including childbearing and child rearing. As these are the very same activities considered the functional basis of the 'family,' in practice, households are frequently identified using both 'kinship' and 'residence' criteria.

Much of the literature on households is concerned with explaining variation amongst them over time and space. Yanagisako, (2001) explains, 'terms such as 'stem-family household', 'nuclear family household' and 'patrilateral extended household' are based on the configuration of genealogically-defined kin types included in the household – often described as 'household composition' (2001:6930). This in itself generates problems for anthropologists as a genealogical link is assumed to form the structural core of the family unit. Yanagisako points out the fragility of this assumption that people who are linked genealogically have the same social relations. 'Assuming the labelling of a household as a 'stem-family household' captures its organisational structure and function.' (2001:6930)

Yanagisako argues a stem-family household found at one time and place does not necessarily share the same organisational dynamics as a stem-family household at another time or place. Therefore, a household or social unit is not simply defined by its genealogical links. Households with the same genealogical composition in the same community can differ significantly in relation to household structures, power, politics and divisions of labour. The illustration suggests limitations in the way stem-family households have been classified by anthropologists. Such definitions do not take into account aspects such as cultural diversity, household dynamics, conflict and contestation. Consequentially, these factors highlight drawbacks for the purposes of this thesis of using 'kinship' as a unit of study. A

review of the literature around kinship provides a sense of limited elasticity in that it does not allow for variation between households in the way they are organised and function on a day-to-day basis. As this thesis explores, household dynamics, power and contestation play a role in shaping domestic electricity consumption.

2.3 'Households' and 'family' contemporary challenges for anthropology

During the past few decades profound demographic changes have been taking place all over the world. But particularly in Europe-America societies where living arrangements such as never marrying, cohabitation and single-mother households have gained importance (Keilman 1998, Swartsz 1998, Hall, 1986). In these societies fertility rates have been on the decrease, life expectancy on the increase and divorce rates have increased. Household size has reduced and the number of households is increasing. Keilman (in Fue and Heaton 1996:1) attributes such trends not only to industrialisation and modernisation, but also to, 'changing attitudes towards traditional family values, gender roles, marriage and parenthood.' Other studies (e.g. Finch 1994) raised concerns about the moral decline of family life due to rampant individualism. In contrast, sociologist Giddens (1998) firmly refuted that post-war industrialisation brought about family decline. Giddens argues, 'there is only one story to tell about the family today, and that is democracy', achieved through values of 'equality, autonomy, decision-making through communication and freedom from violence.' (Giddens 1998:93)

Although anthropological studies of families have adapted over time they generally focus on the effects of industrialisation and urbanisation. For example, in recognising changes in family patterns in the 1960s Goode (1963) points to such change being the result of macro-economic change, 'the relaxation of world trade barriers, globalisation, industrialisation and urbanisation all opened up new challenges for anthropologists defining and classifying households.' (Goode 1963:375)

Segalen (1984) expands on how these political and societal trends have carried implications for anthropology explaining some of the difficulties in classifying households or residential groups who move through some form of seasonal cycle of dispersal and concentration. At a micro level, Segalen explains how anthropologists experienced difficulty trying to handle the movement of people between dwelling units and whether or not to define these as a single unit. Recently, Rouse (1991) and Schiller et al. (1995) raised questions as to whether members of residential units located in different nations and

even on different continents can constitute a single household. Boundaries are blurred due to geographic mobility.

Bender (1967:493) offers useful context as to how social science scholars dealt with the concepts of household and family with greater precision in the late 1960s when 'the household was perceived as a residence group carrying out domestic functions whereas family was likened to kinship groups'. Despite the concepts being separated in this way, Bender points out the implications co-residence and domestic functions have upon defining 'household':

> Household is still burdened by the inclusion of two social phenomena that are logically distinct and vary somewhat independently: co-residence and domestic functions. Social groups, co-residence and domestic functions – often thought of as aspects of a single social phenomenon labelled by the term "family" – are in fact semi-independent variables. (Bender 1967:493)

Clearly, the concept of family as a kinship group requires further understanding. It is thus useful at this stage to steer away from kinship and take a closer look at the concept of family in western societies.

2.4 The rise and demise of the nuclear family

One version of family often cited in anthropological and sociological studies is that of the 'nuclear family', also referred to as the 'elementary family.' Collins English dictionary defines a nuclear family as, 'A primary social unit consisting of parents and other offspring.'

Traits of nuclear families are that the family presents itself as an independent 'unit' where there is a strong dependence of each member on every other member of the family. To understand the circumstances by which the nuclear family came into existence, it is useful to understand the historical context behind its development. Our ideals about contemporary family life in Britain are conditioned by the beliefs about what families used to be like in the past, particularly the period before the outbreak of World War II. Such perspectives (e.g. Gee 2000, Coontz 1992, Hareven 1992) form the basis for an ideology of the modern 'ideal' family and reflect upon the past by assuming there was once a "golden age of family life" typically depicted as existing between the 1950s and 1960s (Press 2009:139).

Typically, but not always, adults in the nuclear family are married. However, some anthropologists including Weston (1991) challenged traditional hetero-sexual assumptions. Although such couples are most often a man and a woman, in response to social change the definition of a nuclear family has since

expanded with the advent of same-sex marriage. Anthropological research identified so much fluidity in family formation that the term was adapted to 'nuclear family complex' in which the roles of the husband, wife, mother, father, son, daughter, brother, and sister are embodied by people whose biological relationships do not necessarily conform to the western definitions of these terms.

Closely related in form to the predominant nuclear-family unit are the 'conjugal family' or 'consanguineal family', 'the conjugal family knit together primarily by marriage consisting of mother, father, their children, and some close relatives. The consanguineal family, on the other hand, typically, groups itself around 'a unilineal descent group known as a lineage, a form that reckons kinship through either the father's or the mother's line but not both.' Anthropological and sociological studies argue the stability of the conjugal family depends on the quality of the marriage of the husband and wife, a relationship that is more emphasised in the kinds of industrialised, highly mobile societies where people reside away from their kinship groups.

One of these sets of beliefs centres on the assumption that families in the past were large, stable, harmonious units. According to Mitchell (2006:30) 'a popular perception (often based on media images and stereotypes) is that people from this era grew up in extended or multigenerational family living structures.' Younger adults would move out from their parental home for a marriage lasting a lifetime.

Gee, (cited in Mitchell 2006:30) points out, 'central to these stereotypical images is the belief that youth transitions into adulthood were universal, standardised, and compressed into a relatively short period of time. Families are reputed to be virtually identical, that is, families were conceptualised as homogenous or "monolithic".' In contrast, contemporary transitions to adulthood are commonly seen as more chaotic due to the 'rise of the nuclear family' and the decline of the family as a result of the changes associated with socio-demographic, cultural and economic conditions including individualisation, secularisation and women's entry into the labour force. Coontz summarises, 'by the 1950s, the nuclear family was considered by many to be a new cultural ideal, based on a unique and contemporary conjuncture of economic, social and political factors' (Coontz 1992:28).

A useful paper which helps to understand the nature of extended family households is that by Klocker et. al. (2012). Klocker et. al. point to the growth of extended family households in the Industrialised West being a result of an ageing population, cultural diversity, rising property prices and extensive years spent in education. Klocker et. al. conducted participatory interviews with extended families in Australia

exploring how resources were shared through a desire to care for and support family members. Klocker finds in such households, the pooling of resources brings about potential environmental and economic benefits. Klocker also questions the 'sanctity of the nuclear family' (Klocker et. al. 2012:2240) observing how people are arranged within extended family households and spaces utilised. According to this study, extended family households find their direct energy consumption is curtailed when household members share appliances and domestic practices such as washing and cooking. Extended family households also make indirect energy savings as domestic appliances are pooled thus generating embodied energy savings.

Interestingly, Klocker argues the current policy agenda has failed to reduce domestic resource consumption and waste production because it has not been informed by a thorough understanding of what happens inside the home and calls for closer analysis of prosaic activity at the household scale. The empirical analysis within this thesis is an example of the type of household scale research Klocker et. al. are calling for.

What emerges from Klocker's study is an appreciation as to how complex extended family households actually are. Some extended households may appear to be living together, but on a day-to-day basis they operate in separate spaces, thus as Klocker puts it 'living together but apart.' Other extended households who shared spaces considered themselves 'treading on each other's toe's', and planned to shift to separate dwellings at some point, suggesting their current living arrangement was temporal, thus fluid.

Havilland (2009) argues, the present-day nuclear family structure is often perceived to be in a crisis state but point's out it is a natural churn caused by macro-societal trends emerging over time. Havilland's viewpoint suggests less structure and pattern to the nuclear family today than there has been in the past largely attributed to emerging macro-societal trends. The decline of the nuclear family has been attributed to gender roles and a shift in balance of power towards females. Young and Willmott's highly cited study of *The Symmetrical Family* (1975) illustrated how married couples were increasingly moving towards an egalitarian partnership characterised by a relationship of sharing and negotiation. They perceived this as a more 'progressive' family structure present at the time in middle class families, but percolating down working class sections of society. Indeed, since the 1950s many cultural changes with respect to the role of women in families and society at large have taken place. Giddens describes a 'post traditional society in which men and women are freed from the roles and constraints associated with

traditional social ties' (Giddens 1992:479). Such societal and cultural changes have led to increased fluidity in household form and function. Where relationships do remain on track it is typical for men and women to share domestic tasks while taking care of children at the same time. Mitchell argues, 'although women tend to be the primary caregivers in most societies, they always serve other functions as well, including contributing to the economic well-being of the family unit' (Mitchell 2006:183).

With women playing a greater role in contributing to the economic wellbeing of the family unit they become much more socially active and less dependent upon their male companions. With this balance of power we now have more opportunity for men *and* women to negotiate, contest and conflict in an environment whereby power is shared jointly by men and women. Of course, as this research illustrates there are exceptions, particularly in households where the occupants are of an older generation following a traditional path in relation to roles, responsibilities and the division of domestic practices.

2.5 Household transition and fluidity

So far this chapter has demonstrated the socio-demographic, cultural, attitudinal, economic and technological changes that have taken place since the 1950s. At the micro level, these changes play a role in reconfiguring household and family structures. A key theme emerging during this period is centred on the movement of people and increased probability that people are less likely to experience permanency in their living arrangements, making their life course and experiences much more 'fluid.' Anthropological and sociological theories of family structures have revolved around the theme of societal change outside the home and how it impacts upon family structures and household composition. The focus in this chapter now moves onto some of the trends emerging since the 1950s to help understand the nature of fluidity at the micro, household level.

2.5.1 Home staying and home leaving

A factor contributing to a decrease in household size is the timing of the departure of grown-up children from their parental home. Schwarz states, 'the propensity to leave the parental home increased substantially between 1961 and 1982 (Schwarz 1988:5). Among the reasons he gives are a tendency towards independence amongst young adults and improved economic conditions which made it less necessary for young people to contribute to family income.

Mitchell (2006) offers a broader contemporary perspective outlining the multi-faceted characteristics determining the timing and nature of this event:

> Characteristics such as gender, family structure, socio-economic status, race/ethnicity, intergenerational relationship quality, school attendance, labor force activity, personal income and region/community size can profoundly shape the nature of this life course event (Mitchell 2006:67).

Goldscheider and Goldscheider (1999) cited in Mitchell (2012) point to family disruption in the parental home as a key reason for premature home-leaving; 'children who have experienced a great deal of household change have a high risk of early home leaving due to "conflict at home."' (Mitchell 2012:237). Mitchell (2006) points out, 'one of the main reasons why those with British cultural backgrounds leave home is to seek independence from the emotional and financial security of the home' (Mitchell 2006:70).

Trends in relation to the numbers of young people leaving home are subject to fluidity, often cited as being a result of economic circumstances. In the UK an increasing number or young adults in their twenties and thirties are choosing to live with their parents. This has become a particularly prevalent social trend over the last ten years due to spiralling property prices and a collapse of the labour market; forcing many young people to retain their living arrangements within their parents' home. Data from the Office of National Statistics (ONS) illustrates that while in 1997 one in four men and one in seven women aged 20-34 lived at home, by 2013 over 3 million people aged 20-34 were living with their parents; a 25% increase on the number (2.7m) in 1997. Mitchell (2006) usefully outlines the benefits late home leaving can have for young adults - 'young adults can use the resources of the parental household to expand their educational training, save money, and acquire consumer goods while continuing to live in a supportive family setting.' (Mitchell 2006:73)

2.5.2 Boomerang kids and mature co-residers

Marriage itself, particularly amongst young adults is also subject to relatively high rates of dissolution (Wolf, 1996). Both factors have contributed to the rise of what is known in social science circles as the 'Boomerang Kids' or 'Boomerang Generation.' These terms were initially used by journalists in the USA and subsequently adopted and refined by academics studying increases in adult offspring cohabiting

with their parents (cf. Dey & Morris 1999, Kaplan 2009). Such examples provide a starting point for thinking about complex patterns of familial mobility and fluidity as they impinge on household structures and, in particular electricity resources.

Today, young people are likely to experience less permanency and more movement in and out of a variety of family-related roles, statuses and living arrangements. Mitchell (2006) argues, 'such fluidity has occurred largely in part because of significant alterations to both public realms (e.g., economic, educational, work and technological) and private spheres (e.g., emergence of new family forms and structures, gender roles).' (Mitchell 2006:188) As a result, family-related youth transitional behaviours have become increasingly dynamic, complex and fluid (Corijn and Klijzing 2001, Hogan and Astone 1986, Irwin 1985). Non-marital cohabitation is also a growing trend amongst young adults, according to Wu and Balakrishnan (2005) this living arrangement has been shown to be considerably more fragile than traditional, legal marital unions in most western societies, often resulting in couples splitting up and returning back to the parental home.

Mitchell (2006) provides a useful summary to illustrate social science researchers' use of timescales to define what constitutes intergenerational 'co-residence', 'mature residency' and 'boomerang kids.' Mitchell (2006:64). Such timescales are important to consider, ensuring the terms and findings in my fieldwork are interpreted in the correct way when identifying and describing household fluidity. A study cited in Mitchell (2006) by Mitchell Wister and Gee (2002) usefully defines the timescales confirming separation:

> Typically young adults must be absent from the parental home for spells of at least four months or more to constitute a separation. Remaining at home past the usual age of approximately nineteen is generally conceptualised as "home staying" or "intergenerational co-residence"; whilst co-residence past the age of twenty five is deemed "mature co-residency". (Mitchell 2006:80).

Similar to the measurement of home leaving spells, home returning as a 'Boomerang Kid' is usually measured as a return that consists of a stay of at least four months, after a period away for at least four months. Mitchell (2006) creates a sense that returning to the paternal home has become normalised in contemporary society but can present strain upon family relations, carrying profound implications bringing with it new experiences, roles expectation and statuses; 'intergenerational co-residence as a

result of the boomerang generation can have profound implications for other family members (notably parents).' (Mitchell 2006:62)

Increased individualism is also giving rise to new challenges in household relations, particularly where multi-generations are living under one roof. Hareven (2006) outlines the difficulty synchronising individual transitions with familial ones. Such difficulty can sometimes generate intergenerational tensions and conflicts, especially when a young adult's individual goals are at odds with the needs of ageing parents during this phase of family development. Gerontologists Mancini and Blieszner (1985) highlights the difficulty parents experience in adjusting when they find themselves recipients of boomerang kids or when middle–aged children find their parents moving in with them; which, depending on parental circumstances, results in them entering into what is often referred to as 'sandwich generation' status.

> What may pose a bigger adjustment problem for parents is the "refilling" of the empty nest, when adult children return to live with parents or when aging parents move in with their middle-aged children. Informal conversations and popular media reports suggest that most parents do not prefer to have their children continue to live with them beyond the expected time for launching or resume residence after having moved out. (Mancini and Blieszner 1985:194)

Further research on the causes and reactions to the returning adult children to the parental home is needed. Although current socio-economic circumstances are often depicted as the driver behind this transitory phenomenon, it may represent a new aspect of parenting for which future generations of parents should be prepared.

2.5.3 Sandwich generation

One of the most profound socio-demographic changes taken place in the UK since the 1950s has been the explosion in population. In most industrialised societies people are living longer and an ageing population carried with it positive and negative consequences for family life. On the positive side, there is an additional source of help and support family members can access during a time or need. On the negative side, there are protracted years of care-giving for dependent elders. Mitchell (2006:186) points

out such trends, 'may affect younger adults in a family indirectly, as their middle-generation parents (commonly referred to as the "sandwich generation") may be increasingly responsible for the simultaneous care of the younger and older generations.'

Those in this 'sandwich generation' are typically in their 50s and 60s finding themselves 'sandwiched' between financing their children's education and care whilst also caring for their elderly parent(s). Figures from the Office for National Statistics[2] illustrate over the period 1985-2010 the number of people aged 65 and over in the UK increased by 20 per cent to 10.3 million; in 2010, 17 per cent of the population were aged 65 and over. The number of people aged 85 and over more than doubled over the same period to 1.4 million. In the context of household electricity consumption, these social trends carry significant implications for future electricity demand and network planning. It will be interesting to see how many examples of 'sandwich generation' households are uncovered during the fieldwork phase of this research.

2.5.4 Divorce

One of the most common forms of household transition or fluidity is caused by divorce or separation. This issue is very well documented by social science researchers (cf. Dunlop,and Barns, 1988, Cretney, 1990, McCarthy, , Date? Simpson, 1991), providing useful insight into the level of disruption divorce and separation has upon family and household structures. Attitudes towards divorce particularly amongst women have changed dramatically since the turn of the twentieth century and reform such as the 1969 Divorce Reform Act have helped to increase its prominence as a normalised feature of a life-course and a well-documented social trend.

Although traumatic for those involved, divorce no longer carries stigma for women and the attitudes associated with it particularly amongst peers are far more positive: liberating, freedom, and celebration. Confirming societal acceptance, British divorce rates have increased in spectacular fashion since the turn of the twentieth century; since the 1950s in particular these rates have gathered significant pace. The divorce rate increased six-fold in the period between 1960 and 1980 and went on to peak at 160,000 in 1985 (Marriage and Divorce Statistics 1990). Since then, the number of divorces has remained stable.

[2] http://www.statistics.gov.uk/hub/population/ageing/older-people

Simpson (1994), provides a useful summary of the emergence of divorce as a common phase of a life-course, 'divorce is becoming an increasingly common part of life-course for men and women in contemporary society and the complex re-structuring of economic, emotional and residential arrangements which this sets in train has now become part of the familial environment in which children grow up.' Simpson's perspective offers a very clear picture as to the depth of disruption divorce can have upon households and provides a sense of fluidity, longitudinal transition involving unrest, negotiation and sacrifice. Smart et al. (2001) argues that although divorce does put family members through a period of fluidity and instability, it can actually compensate by empowering children to become actively involved in family negotiations and decision- making. From this point of view 'greater respect and autonomy are accorded to individual members.' (Smart et al 2001:232)

2.5.5 Other emerging forms of fluidity

Other complicated forms of co-residence are also emerging creating new social groups. For example, in 2005 an article featured on the BBC Radio 4 website[3] discussing the growth of a social group who live apart but remain together (LATs). Since then, there has been considerable social policy focus on the family, couples and individual well-being. A study[4] published in 2013 found nearly one in ten British adults voluntarily live separately from their partner, some for personal space issues and others due to the complexities of modern relationships. The study by Birkbeck College at the University of London, the University of Bradford and the National Center for Social Research found:

> The majority of LATs are under 35, eleven per cent of LATs are over 55, nearly two-thirds of LATs live less than ten miles apart from their partner and 86 per cent of LATs report seeing their partner on a daily basis.

Roseneil (2013) explains why people consciously choose to live apart together to protect themselves, often for financial reasons and their children. Additionally, the study showed that nearly one-third of

[3] http://www.bbc.co.uk/radio4/womanshour/2005_22_thu_02.shtml

[4] http://www.bbk.ac.uk/news/living-apart-together/LivingApartTogether_MultiMethodAnalysis_BriefingPaper_22April2013.pdf

adults were not yet ready to cohabitate with their partner, although there was evidence of future fluidity as many report hoping to do so at some point. One-third reported the emotional buffer as a factor, allowing for both greater individual freedom and less risk of a painful break-up. Children, family commitments and work responsibilities were also listed as contributing factors.

Mitchell (2006) sheds light on what we may expect in future in light of increased opportunities for women, 'as more women attain professional degrees and careers, it is reasonable to assume that we will continue to see a small and growing number of "commuter" marriages and dual residences of orientation.' (Mitchell 2006:183) Additionally, a number of couples continue to live together despite separating, often tied to economic circumstances such as recession and/or property slump and is in itself often subject to transition or fluidity once such circumstances improve.

2.7 Conclusion

Exploring contributions from anthropology and other social science disciplines has helped to consider whether the concept of 'household', 'family' or 'kinship' is of more use as a 'unit' of study when focusing on domestic electricity consumption. Electricity consumption is a 'by-product' of the occupants carrying out their domestic functions within the household unit, therefore from this perspective, 'household' is a representative definition. As the literature finds, the intricacies of daily routines, activities, balance of power and politics going on within the household cannot be ignored as it is ultimately the engine driving the pace and complexity of modern family life, particularly since the 1950s.

During my empirical fieldwork I investigate to what extent household fluidity is determining patterns of electricity consumption within the home. Amongst other issues, I consider whether fluidity impacts upon the timings of domestic practices, where in the home practices are conducted and whether debates in relation to electricity consumption is common in fluid households. The literature discussed in this chapter contributes to an improved understanding of contemporary household fluidity. Since the 1950s, societal trends in the form of divorce, birth rates and the development of the sandwich generation and boomerang children have swept across westernised society creating fluidity in household circumstances. Family and household life is subject to these trends stirring up new dimensions and dynamics that threaten household stability, forcing the movements of people over time

and place. The literature illustrating contemporary forms of fluidity and its growing prominence are important for energy planning and network management.

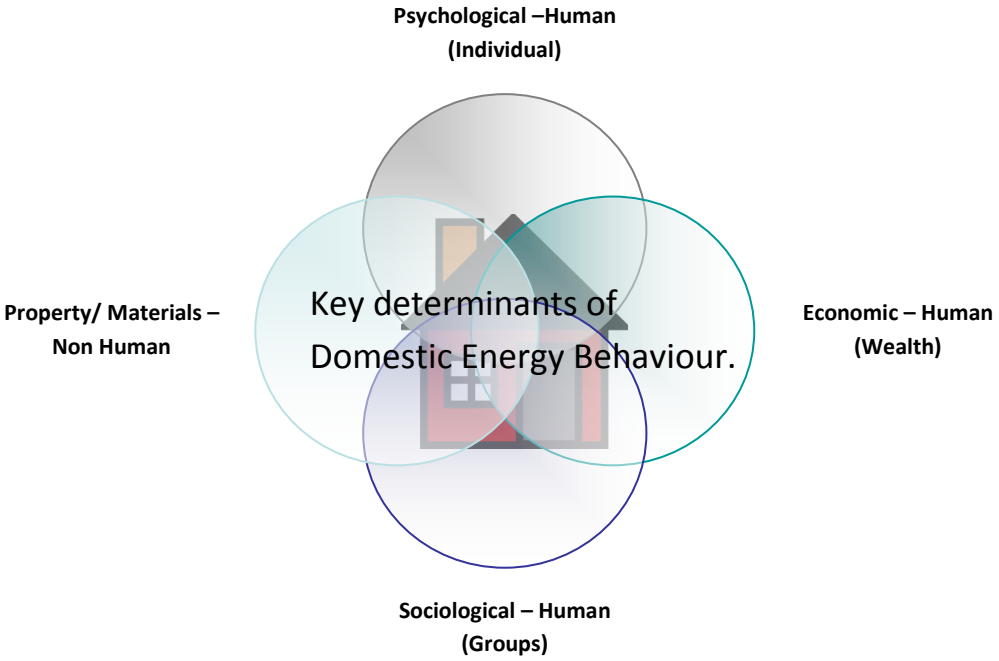
Chapter 3: Introduction to domestic energy use

Understanding the drivers of domestic energy use requires an interdisciplinary approach utilising theories from anthropology, economics, human geography, politics and social psychology and sociology.

In this section a literature review is conducted encompassing recent empirical studies related to domestic energy use. By incorporating the literature in this chapter a thematic framework will be constructed around practice-based accounts of energy use considering the changing socio-technical and economic landscapes impacting upon households.

The scope of the literature is focused around the four main aspects influencing domestic energy behaviour, illustrated in Figure 3.0 below:

Figure 3.0: Key determinants of domestic energy behaviour



The majority of literature around drivers of domestic energy behaviour and consumption is based around these four interlinking factors. Although this section examines the literature describing each of these factors independently, they are all linked. Reviewing the practice base informs themes to explore during the qualitative fieldwork element of this thesis.

Chatterton (2011) usefully sets out the four disciplinary approaches used to understand domestic energy behaviour of individuals: economic, psychological, sociological and educational theories. The four-way division of disciplinary contributions also draws on Keirstead (2006).

Economic theories treat energy as a commodity, 'Consumers will adapt usage in response to price signals.' (Chatterton 2011:6). Whilst evidence exists of short-term responses to increases in energy prices, this is affected by other factors, such as cold weather which tends to increase energy usage whatever the cost. 'In the long-term, there is even less evidence that people respond well to purely economic signals' (Owen & Ward 2010b:7).

Psychological theories argue energy use can be, 'Affected by stimulus-response mechanisms and by engaging attention.' (Chatterton 2011:6). This suggests that people will respond to information regarding their energy usage, such as Home Energy Displays (IHDs), or billing information providing salient information in a manner that allows, and encourages, them to reduce their usage. The impact of psychological accounts of energy consumption is also considered, with particular emphasis on the interaction between economic and psychological factors in the development and maturation of behavioural economics – an emerging approach identified by Chatterton as an important feature of contemporary literature around domestic energy use.

Sociological theories argue energy use is, 'largely invisible, energy systems are complex, and daily practices are significant' (Chatterton 2011:6). The approach is orientated around the view that people do not directly use energy, instead we carry out a range of activities or 'practices' that lead to the consumption of energy: we make ourselves warm, we cook, or do our laundry etc. Practice theory is covered in detail later; for now, Chatterton emphasises how discrete different activities are, and how each activity will require particular policy targeting in order to achieve changes in outcomes.

Educational theories focus on energy use as a skill, 'it is learned through experience in specific situations' (Chatterton 2011:6). Chatterton highlights the differences between energy users, emphasising they are not a homogenous set of individuals. All have complex world-views that reflect different levels of skills, understanding and motives when it comes to their use of energy. These

differences arise through how people learn about energy use and can lead to some significant differences in use patterns, for example, between people who are accustomed to pre-payment meters and those who use direct debits.

Set out independently, each of these four theoretical approaches highlight different aspects of energy behaviour. In addition, whilst these theories all take distinct approaches to looking at energy behaviour, they can be split into two quite different groups, based on: 1) how they position the individual disciplines such as sociology, social psychology and 2) human geography and anthropology; the latter increasingly providing insights into patterns of energy consumption.

Energy behaviour is shown to be influenced in a range of complex ways by factors such as price, awareness, trust and commitment, including a sense of moral commitment. The multi-disciplinary nature of energy behaviour is best illustrated in Fig. 3.1, here the relationship between independent variables and each of the theoretical approaches to domestic energy behaviour can be seen. Illustrated in this way we can also identify demography and income as key variables determining domestic energy behaviour.

Variables Influencing Energy Behaviour within the Domestic Setting							
Theoretical approaches used to understanding drivers of energy behaviour in the domestic setting.	Demography (age, gender, ethnicity)	Income	Tenure	Build form (and age)	Culture	Household Size (Number of occupants)	Rurality
• **Psychological**	✓	✓			✓		✓
• **Sociological**	✓	✓			✓	✓	✓
• **Economic/Political**	✓	✓	✓	✓			
• **Practice / Behavioural**	✓	✓		✓	✓	✓	✓
• **Technical / Material**	✓	✓	✓	✓			✓

Social science-based theories of energy behaviour have become more prevalent over the last decade; driven by desire by government to develop better understandings of energy behaviours in order to develop and implement more effective energy policies, as the UK makes its transition towards a low carbon economy.

I now explore in greater detail two theoretical perspectives identified and introduced previously, (1) social psychology and (2) economics.

A large amount of work has been done in the disciplines of psychology and economics constituting a significant body of literature focusing on energy use behaviour. While the literature in each of these traditions is diverse and covers a range of empirical contexts, they share a common focus on the individual as the central choice-making agent in everyday energy use. The next section considers these two perspectives in further detail.

3.1 Neo-Classical Economic Accounts of Energy Use

Neoclassical economics has traditionally been used to explain the impact of pricing on supply and demand for products and services. It is often cited to explain consumer demand for domestic energy. Pollitt & Shaorshadze (2011) provide a useful appraisal of neoclassical economics; describing its emergence and development to what has become known over the last fifty years as behavioural economics. 'Neoclassical economics theory is well developed and mainstream in explaining how price affects market supply and demand', (Pollitt & Shaorshadze 2011:2).

Rational choice theory was developed in the early 1960s by sociologist George Homans and has historically been a dominant paradigm in neoclassical economics, but has found itself broadening out into other social science disciplines such as sociology, anthropology and political science. Pollitt & Shaorshadze (2011) argue this theory has become out of date and is now unpopular in explaining domestic energy consumption. They criticise rational choice theory as it tends to focus on how the individual evaluates the economic benefit of taking a particular course of action without considering what impact this may have on others. 'It is therefore too individualistic in its approach and does not focus on macro-economic factors which are likely to impose on individuals.' (Pollitt & Shaorshadze 2011:2).

Another possible limitation of neoclassical economic theory offered up by Pollitt and Shaorshadze is its rigid nature, in that it assumes, 'people behave rationally in response to pricing signals.' (Pollitt & Shaorshadze 2011:2). This notion is supported by empirical evidence that behaviour deviates systematically from what traditional neoclassical models of economics predict. Neo-classical

economics attracts criticism in that it neglects the complexity of behaviours for different occupants within a single household. (Wheelock and Oughton 1994, Kooreman and Wunderink 1997).

Practical research by Reiss and White (2008) provide further challenge to neoclassical and economic theory using five years' worth of billing data for a random sample of 70k Californian households. The research illustrates how public appeals for conservation and information had a powerful effect on consumption over and above that of pricing. Many of the shifts in consumption by households in the study were in response to crisis conditions when it was clear that electricity supply was limited; consumers were not reacting to price signals alone but also to the dilemma of limited energy supply. Arguably, the work of Reiss & White could become more relevant over time if electricity supply margins continue to shrink in the UK; making this of greater importance for future network planning. Reducing consumption in order to conserve energy supplies is not something which is currently in the mindset of the majority of UK domestic energy consumers. An event such as terrorism or bad weather causing damage to the UK's energy infrastructure could change this mindset in a short space of time, as it did in Japan following the Great East Japan Earthquake in 2011 where domestic consumers were seen to 'voluntarily reduce their peak electricity consumption', (Energy Economics 39, 2013:296-304).

3.1.2 Economic theories: Key contributions

Studies taking an economic perspective argue energy is a commodity and consumers adapt their usage in response to price signals. According to this theory, we would expect financial incentives to have some impact on energy-using behaviour and energy-related investments, with the size of incentive affecting the scale of the response. Jackson (2009) demonstrates this in their review of demand response programmes in the USA; developed in response to the energy crisis of 2000-2001 in the western United States. Since then much attention has been given to boosting demand response in the US electricity market. Regulators in many states were investigating whether customers would respond to higher pricing by lowering demand and if so, by what level. A survey was taken from 15 pilots, experimenting consumer reaction to dynamic pricing of electricity. Jackson's study finds conclusive evidence that domestic consumers responded to higher prices by lowering usage. Time-of-use rates induced a drop in peak demand that ranged between three to six percent and critical-peak pricing tariffs induced a drop in peak demand ranging between 13 to 20 percent. When accompanied with enabling technologies, the latter set of tariffs led to a drop in peak demand in the 27 to 44 percent range. The magnitude of price response depended upon several factors, such as the magnitude of the price increase, the presence of central air conditioning and the

availability of enabling technologies, such as two-way programmable communicating thermostats and always-on communication systems that allow multiple end-uses to be controlled remotely.

In the UK, Owen and Ward (2010) indicate possibilities and limitations to the application of classical economics related to high prices and reduced energy demand. They found household gas customers reduced their gas usage by 12% overall from 2005 to 2007 in response to higher prices. However, in 2008 when the winter was colder, household gas use rose by 3% despite prices increasing in real terms. Therefore, there appears to be some available price-response for household gas, but people are likely to choose extra heat rather than save money if the weather is particularly cold. 'Real price increases for electricity between 2005 and 2007 suggested a modest demand reduction in 2007. In 2008, despite real price increases, demand for domestic electricity rose by 2.4%.' (Owen and Ward 2010b:7) Around one fifth to one quarter of household electrical appliance load could be 'discretionary' or price responsive – mainly wet appliances as people were becoming more aware of peak and off-peak pricing and adapted their washing regimes to take advantage of cheaper off-peak pricing.

Although the Jackson's study in the US is interesting, the electrical load profiles across these states are likely to be different to that found in the UK mainly due to a higher dependence on electrically intensive appliances such as air conditioning units. Nonetheless, their findings around consumer response to electricity price signals and the impact of interfaces used to encourage demand shifts is interesting. Economic perspectives to domestic energy consumption also raise concerns.

Owen and Ward's (2010) take on price movements and demand for gas and electricity is also interesting, during particular bad spells of weather households consciously choose extra heat rather than turning off their heating. It would be interesting to see how price elastic demand heating fuels are against various definitions of 'bad weather', particularly among those in rural areas who often rely on electricity for their main source of domestic heating. Owen and Ward find that electricity is less price sensitive than gas; as evidenced by the fact demand for electricity increased during a period of price increases in 2008.

3.2 Psychological Theories

Much of the literature in this area is centred on human attitudes and perceptions of comfort. Personal values are also considered; each independently steering energy behaviour in the home. Literature in this field also discusses the extent to which people feel personally responsible and

effective in taking action to reduce energy use which is found to be particularly prevalent amongst environmentally conscious individuals.

Several psychologically-based frameworks have been developed that have been subjected to a range of empirical studies and subsequently modified. The literature search and review undertaken suggests that perhaps more than in geography, sociology or inter-disciplinary literatures in domestic energy use, publications from psychologists rely on empirical data, and tend to use larger data sets when drawing conclusions about energy use.

3.2.1 Psychological theories: Key contributions

Psychology has sought to investigate the motivations and drivers of energy use, seeking to overcome 'serious blind spots', (Kempton et al. 1992:1124) in previously dominant economic and technology-focused research, which proceed from assumptions built into what Keirstead (2006) refers to as 'PTEM' (physical-technical-economic models) of energy use.

As Keirstead summarises, there have been several approaches within the discipline, including studies focusing on 'intrinsic satisfaction' associated with saving or avoiding wasting energy, (De Young 1996, Seligman et al 1979), notions of guilt and morality Kaiser & Shimoda (1999) and ethical concerns around energy conservation (Heberlein & Warriner 1983, Katzev & Johnson 1983).

As well as these accounts, a number of researchers have developed or modified decision making frameworks that attempt to model human decision making and applied them to energy use. Perhaps the most influential of these is Icek Ajzen's Theory of Planned Behaviour (ToPB).

The ToPB starts with the position that general dispositions tend to be poor predictors of behaviour in specific situations, and the associated, 'calls to abandon the attitudes concept.' (Ajzen 1991:180). Ajzen argues that while general, or aggregated, behaviour is associated with attitudes; context-specific behaviour is much more difficult to model. Importantly, and in contrast to other more simplistic accounts of behaviour, ToPB is designed to 'deal with behaviours over which people have incomplete volitional control.' (Ajzen 1991:181). The approach is summarised in Fig. 3.3 below:

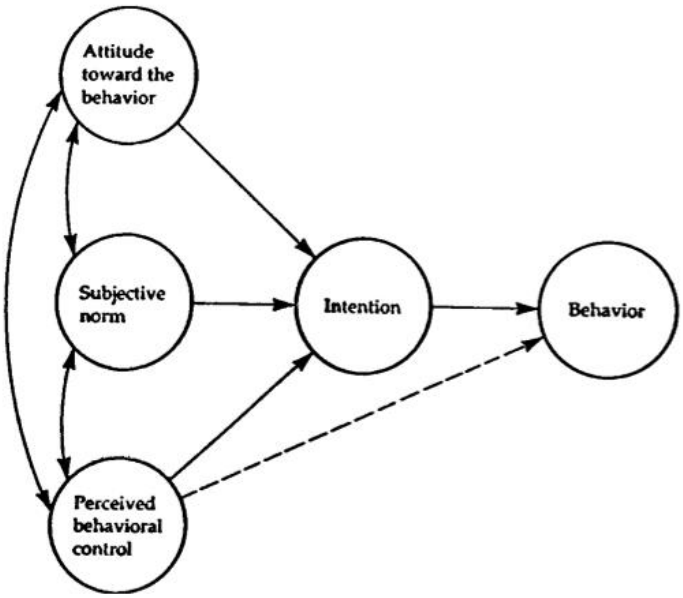


Figure 3.3: - Theory of Planned Behaviour (Ajzen, 1991)

Aspects of behaviour are in large part theorised as non-motivational factors – for example, time, money, skills and cooperation of others. Ajzen suggests that, 'collectively, these factors represent people's actual control over their behaviour. To the extent that a person has the required opportunities and resources, and intends to perform the behaviour, he or she should succeed in doing so.' (Ajzen 1991:183). The combination of intentional and non-intentional factors is not new, as Ajzen acknowledges, and indeed represents the classic psychological axiom of agency – that individuals make decisions based on mental processes and the likelihood of these being acted upon is context dependent. In contrast to other psychological accounts however, is the introduction of perceived control, 'the theory of planned behaviour differs from the theory of reasoned action in its addition of perceived behavioural control.' (Ajzen 1991:183). Such difference is an important aspect of the approach for the purpose of this thesis in that perceived behavioural control differs from another important concept in psychological accounts of behaviour, the 'Locus of Control.' In 1966, Julian Rotter introduced the concept of an internal locus of control to theorise that agency is conceived as being located within individuals, rather than externally. (Rotter 1966, 1975). The concept has been a dominant in behaviour theorisation, cited over 2300[5] times; making Azjen's contribution significant. Rotter's perspective is in contrast with other approaches to energy use,

5 http://onlinelibrary.wiley.com/doi/10.1111/j.1559-1816.2002.tb00236.x/abstract?deniedAccessCustomisedMessage=&userIsAuthenticated=false

most obviously the theories of social practices such as Warde, (2005) for a summary which theorises agency as socio-technically distributed.

Although these papers are now several decades old, Psychology has made a contribution to energy use studies, albeit diminishing in recent years; Loren Lutzenhiser's widely cited review (Lutzenhiser 1993) of the energy consumption literature showed that in 1993 the discipline accounted for 8% of all contributions between 1975 – 1987, while Keirstead's (2006) update illustrated it accounted for only 2% of papers in the 1981 – 2004 period.

Continuing the interest in the role of intention in behaviour outcomes, Poortinga et al. argue that values and intentions are limited, although not entirely redundant, in explaining behaviour. They argue that different forms of environmental behaviour have varying degrees of internal behavioural control, 'the results suggest that using only attitudinal variables, such as values, may be too limited to explain all types of environmental behaviour.' (Poortinga, Steg & Vlek 2004:170)

Indeed, far from their discipline being the simplistic domain of rational action as is sometimes portrayed psychologists have undertaken several studies seeking to address shortcomings in notions of planned or rational choice-based behaviour. These share much in common with sociological and socio-technical accounts, albeit fundamental differences remain. One such commonality is an interest in habits and routinised behaviours. With echoes of Gidden's structuration theory Macey and Brown in 1983 argued that habits are more powerful in shaping everyday activity than intention, while less frequent behaviours (such as purchase decisions) were more likely to be influenced by intentions (Macey & Brown 1983). Mirosa et al. investigated the impact that different 'values' have in driving and prohibiting various energy efficient behaviours, concluding that 'achievement' is powerful in driving new behaviour. (Mirosa et al. 2011:1).

Development of complex frameworks and models continues, as researchers attempt to build context, habits and complexity into the array of factors affecting individual choice. Examples of such complex frameworks include (Whitmarsh and O'Neill 2010:2) who use the notion of 'catalyst behaviours' to study interaction between behaviours undergoing change. In this account when a householder adopts a new pro-environmental behaviour, for example recycling, it may then encourage further pro-environmental actions that may be only indirectly connected. However, they find the evidence pointing towards a spill-over between one pro-environmental action's to another is weak and that self-perception or identity remains a key factor in certain pro-environmental behaviours. The notion of spill-over has also been incorporated into Tom Hargreaves' work (cf. Hargreaves 2011) who found that only a small subset of his participants displayed this catalyst characteristic.

Agent-based modelling (BREDEM and the UK Domestic Carbon Model for example), is developing as a statistical approach to the development of context-sensitive centres of agency (the agents in the models). Of particular relevance is a paper by Natarajan et al. (2011) that seeks to overcome the lack of human-technology interaction in the currently dominant and politically powerful models of domestic energy consumption. They point out that while occupants of buildings are largely absent from these models the fourth assessment report of the Inter-governmental Panel on Climate Change (IPCC) on mitigation states that, 'occupant behaviour, culture and consumer choice and use of technologies are also major determinants of energy use in buildings and play a fundamental role in determining CO_2 emissions' (Natarajan et al. 2011:1). The IPCC authors go on to suggest that building occupant interaction into an occupant-centred model could improve the accuracy and effectiveness of domestic energy modelling in the UK, referring to Raaij and Verhallen's decade-old but frequently cited model as a precedent.

In the development of a new modelling paradigm, Natarajan et al. (2011) draw on and synthesise the findings of Lutzenhiser and Kierstead (discussed above) to develop an integrated, interdisciplinary approach to behaviour and pathways to the development of an agent-based model, founded on an awareness of habits and technology interaction. Natarajan et al. explicitly deal with smart, network-sensitive demand side response to confirm that behavioural approaches are neither simplistic nor naive to the nuances of everyday life.

3.2.2 Feedback

Another important dimension to the literature on behaviour is literature around the role of and effects of feedback on energy consumption (cf. Darby 2010, Hargreaves 2010, Nye & Burgess 2010) provide recent examples of energy feedback research projects in the UK.)

Wood and Newborough's paper (2003) argues two types of information influence people's behaviour; antecedent (general) and consequence (feedback). They suggest that while general or antecedent information may cause behavioural change, citing Winnet et al. (1987) and Denis et al. (1990), what Wilhite and Ling (1995) refer to as the 'fallback effect' often means changes are short lived and often diminish within weeks. Another problem with antecedent information is that people may change their behaviour if they know they are being studied, as is often the case in behaviour change interventions. Wood and Newborough conclude that the fallback and Hawthorne effects (whereby subjects modify an aspect of their behaviour which is being experimentally measured, in response to the fact they know that they are being studied) pose serious problems for the use of general information alone. Indeed, focusing on real time feedback during cooking, they argue that, 'a major untapped route for achieving energy savings in the domestic sector is to identify

and implement means for influencing end users before/during/after they use appliances. It is therefore recommended that policymakers develop and implement actions specifically focused on the points-of-use alongside those already applied at the points-of-sale.' (Wood & Newborough 2003:836).

Abrahamse et al. (2005) cover a wider spectrum of research in their review of intervention studies aimed at home energy conservation, also studying 'antecedent information' (e.g. information or standardised advice tips, or goal-setting) as well as feedback (consequent information). They point out that information may increase knowledge, but it does not necessarily affect behaviour. Feedback is effective to the extent that it provides highly specific, relevant, actionable information, and a means of checking the effectiveness of actions.

Fisher 2008, cited in (Chatterton 2011:32) provides a review of energy feedback from a psychological standpoint and identifies the following features as important in stimulating successful interaction and conservation:

- 'based on actual consumption (i.e., accurate and trustworthy)
- frequent (ideally, daily or more often)
- involves interaction and choice for households
- involves appliance-specific breakdown (given over a prolonged period)
- May involve historical or normative comparisons (presented in an understandable and appealing way.'

As Fischer points out, the more clearly someone can link consumption to specific appliances and activities, the more clearly behaviour patterns become relevant to consumption (and the size of the energy bill). In the longer term, we could add that feedback over time can demonstrate the benefits of better insulation and more careful use of timers and thermostats, or the energy cost of new equipment or increased living space.

3.3 Behavioural Economics

Behavioural economics is often cited as the modernisation of neoclassical economic theory. Prendergrast et al. state behavioural economics combines learning from psychology and sociology and, 'offers insights into the impact of habits, emotions, cognitive capabilities, cultural attitudes and social norms in influencing individual behaviour.' (Prendergrast et al. 2009:10).

In support of the modernisation of neoclassical economic theory Pollitt & Shaorshadze perceive behavioural economics as the next generation of neoclassical theories drawing on insights from psychology and they also perceive a bright future for behavioural economics as, 'a growing and thriving field.' However, they remain clear the theory comes with some theoretical and empirical gaps and limitations; 'those who write about behavioural economics often start from the observation of how individuals behave and then show how this behaviour violates neoclassical economic assumptions.' (Pollitt & Shaorshadze 2011:20).

A key characteristic separating neoclassical theories from the later behavioural economic theory is around people's propensity to behave 'rationally' and 'irrationally.' As discussed earlier neoclassical economic theory conceives of people behaving in a rational, cognitive and orderly way, however the psychology-based behavioural economic theory illustrates the 'irrational' nature of human beings and how this can lead to different outcomes. Pendergast et al., add to this perspective providing an explanation as to the divisions between the two theories, 'behavioural economics differs from that of economics in that it does not make assumptions about what consumers do, but rather observes and models them based on those observations. In particular, behavioural economists do not assume rationality, but test it.' (Pendergast et al. 2008:19).

In the last decade, behavioural economics has increased in popularity, used frequently to contribute to debates around climate change policy. A recent example as to how behavioural economics has been applied in climate change policy circles is Allcott and Mullainathan (2010) who made the case that the theory can be used to inform the shape of key energy policies. Allcott and Mullainathan (2010, DEFRA 2010), Pollitt & Shaorshadze highlight the 'central' role behavioural economics can play in this arena:

> 'consumer behaviour has become central to understanding the climate change debate, if consumer behaviour can be changed to reduce energy demand or make energy demand more responsive in time and space to weather individual shortages of energy, it could be a

significant contribution to facilitating the introduction of climate change policy and induced renewable policy.' (Pollitt & Shaorshadze 2011:1).

Pendergast et al. suggest a potential limitation in the wider application of behavioural economics is its dominance of 'academic' and 'theoretical language.' (Pendergast et al 2008:6)

Pollitt & Shaorshadze provide a useful synopsis as to how decision makers have utilised economic behavior theory to help inform energy consumption, 'iin order to realise energy savings and emissions reductions necessary to address climate change, decision makers have to consider tapping into behavioural transformation strategies.' Behavioural Economics provides insights that can inform this effort. Behaviours that are relevant to household energy consumption encompass three broad areas (1) energy consumption, curtailment, and habits; (2) energy efficient investments and (3) contribution to public goods (i.e. green energy technologies) and pro-environmental behaviour. (Pollitt & Shaorshadze 2011:2).

3.4 Practice-based theories

Practice-based theory offers an alternative to economics and psychologically driven, choice-based accounts of everyday life. Its application to domestic energy use has developed over the last fifteen years by a relatively small group of social science researchers and anthropologists. It is important to recognise no single over-arching 'practice theory' exists but it is useful to explore how this set of related ideas has been used to shape analysis of domestic energy consumption.

3.4.1 Practice-based theories: key contributions

Alan Warde's paper in 2005 brings together contributions from a second generation of practice theorists including Yolande Stengers, Theodore Schatzki, Andreas Rekwitz, Elizabeth Shove and Kirsten Gram-Hanssen. I now consider their contributions to the field of energy research.

Theodore Schatzki, (1996, 2002) and Andreas Reckwitz (2002, 2005) both made early and influential contributions to the development of practice theory arguing everyday life consists of animated practices. Practice theory provides an alternative perspective to dominant beliefs that everyday life is driven by individuals choosing what to do in response to rational drivers and barriers. Practice theory is useful to this thesis in that it has been applied to 'consumption' with particular attention to 'energy consumption.' One of the key features of practices is they represent the things people do without consciously choosing to and that become almost routine in nature. Reckwitz draws

particular attention to this characteristic in the way practices are thought of as a collection of heterogeneous things, such as ideas, knowledge and skills or devices, which become associated with one another through more-or-less routine enactments:

> 'A practice is a routinised type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.' (Reckwitz 2002:249)

By focusing on the ways in which people achieve outcomes (such as cleaning oneself) through practices (such as showering or bathing) and how the outcomes and the processes of achieving these outcomes change over time and place, we can begin to consider how practices might animate everyday life rather than result from it. In the context of domestic energy use, practices might achieve entertainment, cleaning, cooking, hospitality, study, dining, bathing and so forth.

Strengers account of practices is informed by the work of Reckwitz, Schatzki and Shove starting from the assumption that practices are made up of practical knowledge, common understandings, rules and material infrastructures which 'intersect to create an organised nexus of actions.' (Strengers 2010:14). Gram-Hansen's perspectives of practice theories are particularly useful to this thesis as they focus on change and continuity in practices hinting links with fluidity. Her perspectives provide a link between practice theories and transition theories (Geels 2005, Shove and Walker 2007, Grin et al 2007).

3.4.2 Practices: The focus for enquiry

One of the most striking characteristics of a practice-based approach to everyday energy use is that it treats practices as the focus of enquiry, rather than the people using the energy. For example, a practice-based study will focus on how cooking practices are performed, what context they arise from and what factors have been involved in shaping or structuring them, rather than on why people choose to cook in certain ways. Factors may include infrastructure, technologies, affordability as well as ideas held by the human performers of the practices. The emphasis is focused on the 'socio-technical infrastructures' within the home and how they shape practices.

Practice-based approaches are distinct from other accounts of energy use outlined earlier, which primarily study people. 'From this point of view, understanding social change is in essence a matter

of understanding how practices evolve, how they capture and lose us, their carriers, and how systems and complexities of practice form and fragment.' (Shove 2010a:1279)

The second key feature of the practice-based approach to everyday energy use is the way practices are seen as iterative and emergent, rather than the outcomes of choice making agents, or powerful structures. Practices are seen to emerge from specific socio-technical contexts. In this respect they can be thought of as co-evolving; adapting to and with their surroundings. Spaargaren describes this as being what emerges when people, 'make use of the possibilities being offered to them' (Spaargaren 2003:688).

The notion that non-human 'actors' have a role to play in causing certain outcomes or 'behaviour' draws on the actor-network theory of Bruno Latour. Shove (2010) states:

> Put simply, roads, railways, freezers, heating systems, etc. are not innocent features of the background. Rather, they have an active part to play in defining, reproducing and transforming what people take to be normal ways of life. The key insight here is that the material world and related systems of production and provision are important in organising, structuring and sometimes preventing certain practices. (Shove 2010a)

Shove (2010b), also argues attempts to integrate individual behaviour models with social practice theory are 'doomed to failure', stating that 'It is useful to be clear about the incommensurability of these contrasting paradigms, and hence about the impossibility of merger and incorporation.' (Shove 2010b:1279) Practice theory provides a plethora of new routes to understand and explain behaviour; similarly, it attracts a broad range of potential responses.

3.4.3 Practice theory vs choice-based understandings of behaviour

Fig 3.4 below helps to illustrate the characteristics and attributes of choice and practice-based accounts of energy use. Central to this thesis is the nature of fluidity within households and the impact it has upon shaping patterns of domestic electricity consumption. The unit of analysis is the household and I explore how domestic practices are conducted within it. The study will lean towards exploring practice-based accounts of energy use adopting an ethnographic approach observing householders in their natural household environment.

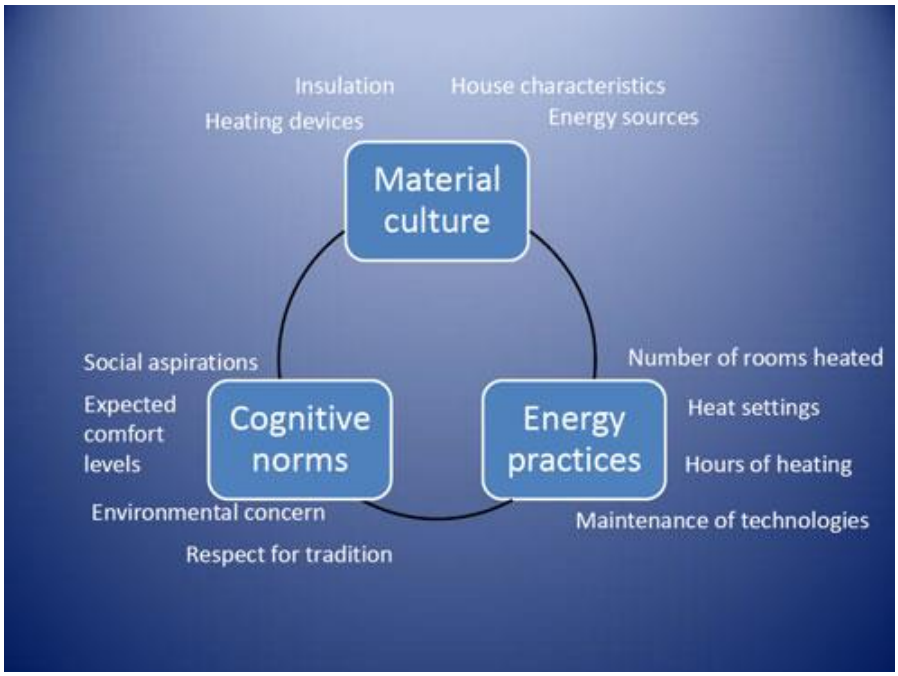
Figure: 3.4 – Choice-based accounts of everyday energy use vs Practice-based accounts of energy use.

	Choice-based accounts of energy use.	**Practice-based accounts of energy use**
Unit of analysis	The individual.	Domestic practices (e.g. cooking practices, bathing practices, entertainment practices).
Drivers of activity	Choice, based on drivers and barriers, social norms, self-interest, utility maximisation.	Socio-technical contexts, rules, know-how, knowledge, habit, technology, skills, preferences.
Disciplinary heritage	Economics, psychology, sociology.	Anthropology, sociology, science, and technology studies.
Levers for changing behaviour	Price, information, knowledge, persuasion.	Changing social, technical and economic relationships that structure emergent interaction.
Methodological approach	Survey, interview, focus groups, discourse analysis.	Ethnographic, observation, socio-technical context description.

3.5 Integrated Frameworks

In addition to the integrated framework offered by Chatterton (outlined earlier), another example is the 'Energy Cultures Framework' developed by Stephenson et al. (2010). The framework is a multi-disciplinary integrated model and posits that energy behaviours should be understood as outcomes of the interaction between cognitive norms, material culture and energy practices. It incorporates social practice, socio-technical systems and wider societal factors however, unlike practice-based theories this framework incorporates the role of individual cognitive norms within its three broad dimensions (material culture, energy practices and cognitive norms) as illustrated in Fig 3.5 below.

Figure: 3.5 the Energy Cultures Framework Stephenson et al. (2010)[6]



Stephenson applied the three components above whilst studying energy consumption behaviours New Zealand over a period of three years. Although Stephenson's framework provides useful prompts to use whilst conducting ethnographic research, it may not be possible to capture data on each component given the timescales of this research.

3.6 Conclusion

In reviewing the literature around energy behaviours it is neither possible nor reasonable to identify a single theory that will explain all things. Academic disciplines view the same issues through their own completely separate lenses; however, as the previous chapter also highlighted household circumstances have become too varied and complex for this to be possible.

Psychologically-based theories are complex, diverse and often criticised for their individualistic focus ignoring the impacts of social factors upon behaviour change. Society does have an impact on the agency and power of individuals and there is an abundance of evidence to quantify this. However, it would be naive to reject such theories as the depth of empirical studies offered by this discipline offers new perspectives to help understand domestic electricity use. Psychological perspectives from Fisher (2008) are particularly useful to bear in mind when conducting the qualitative fieldwork for this thesis. For example, it will be interesting to see whether those interviewed and (where applicable) their co-residers make links between their energy consumption and specific electrical

6 Images from http://www.otago.ac.nz/oerc/Symposium%202010/Presentations/7.%20Rob%20Lawson%20-%20Energy%20cultures%20framework.pdf

appliances within their home. Energy tours will provide an empirical perspective on this area of domestic energy behaviour. Psychological perspectives can explore whether the installation of energy efficiency equipment such as solar PV or informative devices such as smart meters with supporting IHDs acts as Whitmarsh and O'Neil, state, as a 'catalyst' to changing other behaviours such as turning electrical appliances off standby.

Fieldwork will incorporate socio-psychological viewpoints; consumer perception of institutions such as the media, energy suppliers and central Government all play their part in persuading householders to take the desired actions directed to them. Panic buying of fuel at our petrol stations across the UK demonstrates how influential these institutions can be in shaping behaviour. Other externalities such as the weather have also been shown to influence consumer behaviour and cannot be ignored; during cold spells, bulk buying of oil and LPG are examples of such influence. Interestingly, the literature implies consumers do not interact with electricity in the same way as other fuels, something to note for the fieldwork phase of this thesis.

Economics-based theories, particularly the notion of behavioural economics resonates strongly with wider CLNR activities. Behavioural economics offers a growing branch of energy studies and principles from the approach that will be explored during the fieldwork. It will be interesting to see how householders in my sample respond to financial incentives such as time-of-use tariffs (ToU). A major challenge in trying to encourage domestic electricity consumers to reduce or adapt their electricity use is to convince them of the economic benefits that can be achieved over time by adapting their behaviour. The economic benefit to consumers is never immediate and relies on a period of time to accrue before the consumer can realise the economic benefit, therefore the perception of the consumer is a lack of 'immediate benefit' which may test participants' willingness to remain engaged in the research.

The recent use of practice theory in energy research draws heavily on significant contributions since the late 1990s. In particular the contributions from Schatzki, Gram-Hanssen and Strengers have been highly influential in developing and sustaining interest in practice theory particularly in energy research.

Chapter 4: Research Methodology

Firstly, I will define how the theme of fluidity emerged and how it became the focus of this research. In my current employment as a senior research and policy officer with National Energy Action (NEA) I frequently conduct household interviews capturing qualitative and quantitative data in relation to domestic energy efficiency and consumption. In previous studies undertaken outside of the CLNR programme I had made an observation that many households interviewed had experienced a change in household composition or circumstance and were therefore subject to fluidity. I had developed an interest in understanding how such fluidity influenced general energy (water, gas electricity and solid fuels) consumption. In the early stages of the CLNR programme this theme was discussed with my supervisors and I agreed to investigate this further as I undertook initial CLNR interviews.

Following an initial six household interviews I was taken aback by the prominence of such fluidity and decided to use this theme as the core focus for my thesis whilst understanding the focus would be limited to electricity consumption rather than the whole fuel and utility mix per-se. All CLNR interviews were undertaken using a wider analysis framework to which I played an integral part in designing. The following section provides a detailed account of the methods adopted and tools used to generate qualitative and quantitative data.

In developing the qualitative methodology for this study, various activities were undertaken to assess the most appropriate approach to this research. The research methods adopted drew on existing literature to design research instruments. Working in partnership with the CLNR social science team I played an active role in consulting an expert advisory board to facilitate in-project peer review of the approach. Having an active role in feeding our collective methodological approach to this group helped me to refine and sense check the research approach.

4.1.1 Choice of technique: A mixed methods approach

Following reviews and expert consultation both qualitative and quantitative research methods are applied to this thesis. A mixed method approach often referred in social science research to as ‘the new’ approach (Bazeley 2012). Greene (2008) argued the messy nature and complexity of social science research demands the application of mixed methods and the two approaches have always co-existed comfortably. Applying both methods in this thesis sought to generate high quality empirical and statistical data.

Qualitative data on energy-related practices was generated through face–to-face interviews in the homes of the respondents. Interviews can be a rich source of data Burgess (1982) argues it provides

the opportunity 'for the researcher to probe deeply, uncover new clues, open up new dimensions of a problem and to secure valid, accurate, inclusive accounts that are based on personal experience.' (Burges 1982:101) Quantitative data was captured by installing data monitors in respondent homes to measure daily electricity consumption (kWh) further detail as to electricity data metrics supporting this thesis is provided in section 4.3 below.

4.1.2 Home tours

Home tours, or energy tours, have been widely used in practice-based projects and literature as a tool to engage participants with the technology and the environment in which the practice takes place (Pink 2005, Gram-Hanssen 2010, Hargreaves Nye et al. 2010, Halkier and Jensen 2011). These tours typically involve the informant spending up to an hour showing the researcher around their home while notes are taken or videos recorded. A prompt checklist was sometimes used to ensure different stages of the practice or home was included. The purpose of the home tour varied from using appliances as a prompt to engage participants with another area of energy use or to capture all the stages of a particular practice. Social anthropologist Pink (2005:275) offers a particularly useful approach when studying the intricacies of laundry practices within the domestic setting. Pink focused on the areas within the home where laundry was left out by occupants for collection, transferred, washed and dried. Whilst discussing these processes Pink usefully captured ethnographic data about the sensory aspects of decision-making about laundry, stating: 'The data this video ethnography produced includes informants' verbal and embodied representations of their sensory, emotional and other experiences and practices of laundry in their homes.' .

In some cases householders were not told about the 'tour' element prior to the in-home interview as the researcher did not want the participant cleaning up beforehand as they want to capture the house as it was lived in. Applying advice from Wood and Newborough (2003) who observed 'fallback' and 'Hawthorne' effects (whereby subjects modify an aspect of their behaviour which is being experimentally measured, in response to the fact they know that they are being studied.)

4.1.3 Research conducted

Participants were recruited by telephone to take part in face-to-face visits. British Gas (BG) provided lists of customers who had explicitly consented to being contacted by the researcher to take part in further research. The research analysed and presented in this thesis took place over three time periods, conducting the interviews during these periods enabled me to consider the effects of seasonality on domestic electricity consumption:

- May to September 2012
- November to March 2013
- August to September 2013

Each interview was assigned an anonymous reference number. These numbers and names (changed to protect anonymity) are used as a point of reference in the findings and analysis section of this thesis.

4.1.4 Instrument design

To help shape the design of research instruments for the fieldwork phase, it was necessary to review the existing literature focused on households as a unit of study and the factors influencing domestic energy use. Much of the literature complements the ethnographic approach adopted during the fieldwork phase where the researcher is exposed to kinship relations and everyday family life across multiple households. Ethnographic research is deeply embedded within the study of anthropology where the researcher observes, or becomes part of a group to understand human behaviour, social networks and culture.

Each household interview was separated into four parts:

1) Formalities

The first five to ten minutes were spent explaining the purpose of the interview and how the research fitted into the wider energy policy context of decarbonising the electricity grid whilst reducing demand at peak times. An explanation was also provided as to the data protection instruments and guidelines in place to safeguard the data and information generated from the interview. An information sheet about the wider objectives of the project and the data protection assurances in place was provided to each respondent. Before each interview took place, respondents were asked to sign a consent form.

2) Introductory semi-structured interview

The semi-structured interview focused on building rapport with the participant while discussing their energy use in general terms. These conversations included information about occupancy, major electrical loads, heating regimes, thoughts and feelings about electricity use, seasonality and other temporal factors as well as experiences of and attitudes to new and existing tariffs and technologies.

3) Tour of the participant's premise

Once rapport is built up with residents a tour of the home is undertaken. The tour of the premises is participant-led although the researcher will prompt the participant to talk about all aspects of their electricity use using electrical equipment as catalysts for conversation. Furthermore, the researcher may, with permission, collect multimedia data to further enrich analysis. Tours of the participants' premises are designed so that technologies and everyday items could act as prompts for the participant to discuss their practices. The participation-led approach is reflected in the instrument design which does not constrain the respondent or presuppose the factors which are most relevant to the participant.

4) Semi-structured interview

Finally, a further semi-structured interview is undertaken, this time focusing on linking the practices and materiality's emerging from the first two parts of the visit. The literature around practice-based approaches to domestic energy use was used to inform the structure and design of this interview. The third part of the visit enables a summary discussion of the principle issues as they relate to the participant's context and focuses on the topics of flexibility, peak electricity consumption and key practices with potential for demand-side participation and engagement.

Following each interview I made notes of general interpretations and reflections of key discussion points raised during the interview. These were used to support the audio recordings.

4.2 Qualitative analysis methodology

The qualitative research techniques adopted were designed to allow the drivers, interactions and ingredients of everyday practices to emerge at the point of contact between researcher and participant without imposing preconceived ideas.

The data was analysed using qualitative date analysis (QDA) software package NVivo, which supports mixed methods and collaborative research. The decision to use NVivo was guided by useful studies (Taylor and Gibbs 2010, Beins and Bernard 2012) on the implications of utilising QDA software for qualitative analysis. NVivo also acts as a database for storage and management. NVivo was chosen for this analysis as it enables researchers to collect both the text-based (transcripts of interviews, questionnaires to record technology ownership and household details, notes and reflections) and multimedia information (audio files, photographs, drawings). The data collected was organised

around ‘nodes.’ A node, consisting of a collection of references around a specific theme, was created for each interview. A node associates the data generated at each visit with a unique interview ID.

4.2.1 Analysis

The data captured in the face–to-face interviews are photographs, audio interviews which during the fieldwork were used to capture information about technologies in the home, the dwelling itself, and the household composition. In addition, the iPad is used to capture sketched load curves and floor plans which encourage participants to talk about their energy consumption in different areas of the home over a 24 hour period.

4.2.2 Analytical framework

A set of themes to structure the analysis of the qualitative data was developed. These themes were developed through repeated collaborative discussions with the social science project team during the qualitative research process. Discussions between informants helped validate my own interpretations emerging from the data to ensure the themes were accurate representations of trends and patterns emerging. The framework is made up of a number of themes which emerged from discussions of qualitative research and in accordance with a review of existing literature on household definitions, fluidity and understanding the main drivers of domestic electricity use.

Once the themes were identified they were merged into NVivo and used to interrogate the data in structured ways to identify data that relate to particular questions of interest. These include practices that take place in the 4pm - 8pm period and what participants regard as their most and least flexible electricity use practices.

An explanation of the analytical themes and coding criteria aligned to each theme is illustrated in the table below:

Table 4.2.2: Thematic description and coding criteria

Theme Description:	Coding Criteria:
Accomplishing energy services (ingredients currently assembled to deliver this service.)	Cooking Washing clothes Washing people Household chores Home entertainment Caring for elderly Caring for young DIY Gardening Hobbies
Knowledge and know-how – learned knowledge.	Information – official sources Information – media related Knowledge – know how about energy use in their home Knowledge – accepted wisdoms Knowledge – friends and neighbours Technology – how things work Technology – how to fix things Making do
Technical legacies and novelties – living with existing technologies and adapting to new ones.	Imprints of pre-existing technologies on energy use (e.g. cooking, heating, appliances) Managing existing appliances Coping with faults, inefficiencies Repair and maintenance Domesticating new technologies New technologies – gadgets and appliances New technologies – smart /+ TV New technologies – washing and drying New technologies – fridges and freezers New technologies – cooking New technologies – heating systems New technologies – meters Connectivity – Internet / Mobile
Hubs and environments – Areas within the home used or associated with specific occupants.	Spaces of energy use in the home Kitchens Bathrooms Living rooms Other Spaces (sheds, hobby rooms etc.) Creating environments - warmth, hospitality etc. Creating moods – winding down, gearing up
Rhythms and thresholds- Routines and the timing of energy use.	Mealtimes Bath times Putting the kettle on Chill out/Relax /TV time Homework Morning thresholds – going out to work Morning thresholds – going out to school Evening thresholds – coming home from school Evening thresholds – coming home from work

	Evening thresholds – end of day / go to bed Leisure activities outside the home and energy use
Health and well-being	Aspects of health determining electricity use Medical equipment Good days Bad days Health impacts on practices
Conflict and contestation	Bill payer versus user Wasting electricity Roles and responsibilities Energy efficient/inefficient behaviours
Internal economies - Managing costs associated with energy use.	Pricing and costs Calculating economic savings Managing energy budgets Managing energy supply contracts Managing energy as a resource Energy use and patterns of work Energy use and patterns of care Working at home Austerity and energy use Frugality Wise investment Preparing for the future

4.3 Analysis of consumption metrics

Quantitative data was generated by installing customised metering equipment in participant homes to measure total electricity consumption in kilo watt hours (kWh) at 30 minute intervals. Electricity consumption metrics were collected and analysed across three time bands to calculate total demand and in particular, evening consumption demand including a measurement of the intensity of electricity demand during the evening period. Further detail around the approach adopted to analyse consumption metrics is presented below.

To support the qualitative data generated, electricity consumption metrics were collected and analysed across each of the following time bands to calculate their total demand and in particular, their peak demand and the peak intensity of their demand:

- Band 1: 8pm-8am
- Band 2: 8am-4pm
- Band 3: 4pm-8pm

As a means of representing these three periods of electricity use, the following three time bands are used:

- Average Day Time Electricity Use (AD, 8am - 4pm)
- Average Evening Electricity Use (AE, 4pm-8pm)
- Average Night Time Electricity Use (AN, 8pm – 8am)

4.3.1 24% (4pm-8pm)

The 24% (4pm-8pm) time band is used in this thesis as a proxy to illustrate the percentage of electricity consumption over twenty four hours which occurs during the high load period (4pm-8pm).

4.3.2 Consumption Factors (n:1)

As a means of analysing the extent to which a household's electricity demand is more intensive during certain periods of the day, three consumption factors were calculated. An explanation of these is presented in fig 4.3.2 below:

Table 4.3.2: Consumption Factors (n:1)

Consumption Factors (n:1)	Explanation	Formula
Daytime consumption factor (DCF)	Rate of electricity consumption during the day (8am to 4pm) relative to that consumed during the other **sixteen** hours of the day.	DCF = (AD/4)/ ((AN+AE)/16)
Evening consumption factor (ECF)	Rate of electricity consumption during the day (4pm to 8pm) relative to that consumed during the other **twenty** hours of the day.	ECF = (AE/4)/ ((AN+AD)/20)
Night time consumption factor (NCF)	Rate of electricity consumption during the night (8pm to 8am) relative to that consumed during the other **twelve** hours of the day.	NCF = (AN/4)/ ((AD+AE)/12)

4.3.3 Test cells (TC)

Test Cells (TC) define the type of intervention provided to households involved in the trial and include the introduction of low carbon technology (solar panels) and time of use (ToU) tariffs.

Within each TC, a pre-determined set of social criteria was identified which emerged from the initial review of available literature on energy consumption in domestic settings in chapter. Based on the literature review and working in collaboration with the social science team, critical variables were

identified which formed the basis of the selection criteria for the Test Cells. The variables selected for domestic customers were as follows:

- Energy efficiency rating
- Ages of household members
- Household Income
- Housing Tenure

Table 4.3.3: Proxy measures for thermal efficiency and characteristics

Proxy Measure for Thermal Efficiency	Characteristics of property
Low thermal efficiency	domestic properties of any type built before 1919
Low-medium thermal efficiency	bungalows, terraces, detached and semi-detached homes built 1919-1976 and flats built 1919-1945
High-medium thermal efficiency	flats built 1945-1976
High thermal efficiency	domestic properties of any type built post 1976

Ages of household members

Studies such as Gram-Hanssen (2005) and Gustafsson (2009) have shown clear differences in domestic energy behaviour between those with and without children at home. Those aged over 65 also tend to exhibit different energy behaviours than their younger counterparts, partly because they are more often in the home. In effect, this age-related variable can capture additional information related to occupancy and energy service needs (e.g. for higher levels of thermal comfort). Participants were selected around the following age-based criteria:

- Households with at least one child aged <5 years and/ or an adult aged >65 years
- Households with all members >5 years and <65 years

Household Income

The literature review outlined in chapter 3 identifies income as a particularly powerful predictor of domestic energy behaviour as it plays a role in structuring social, economic, and cultural life thus influencing material surroundings and daily practices. Participants in the study were selected around very broad income categories, which approximate those with income below/above the regional average:

- Household income < £19,999
- Household income > £19,999.

Housing tenure is an important indicator of many things which have been found to influence energy use, not least of which is the potential for investment in energy-saving technologies or home improvements. As a result, for this purpose test cells were populated from households in the following categories:

- Owner-occupied
- Rental (council or private)

While there are observed differences in SAP rating by housing tenure category, these appear to be a result of the age of these buildings and their build type (on average the social housing stock is newer than many of the owner-occupied or private rental stock and less likely to be either detached or semi-detached houses) (Department for Communities and Local Government 2009).

Working alongside the Social Science team at Durham University, 25 face-to-face interviews with CLNR participants were undertaken. These interviews are distributed across the test cells as below.

Table 4.3.4: Completed Qualitative Research

Test Cell		Interviews completed	Interviews used in thesis
TC1a	Smart meter and in home display (IHD)	6	4
TC5	Photovoltaic (PV) generation monitoring	7	1
TC9a	Time of use (ToU)	5	1
TC20	Photovoltaic generation and usage monitoring	6	2
Total		**25**	**8**

4.4 Research tools

In conducting the fieldwork a range of tools were used to capture data including recording software on an iPad[7]. Using the iPad, categorical information about the participants was collected, for example heating and lighting technologies in use and participants were also asked to sketch their floor plans and daily electricity consumption in the form of a load profile. The iPad was used to add metadata to records to aid analysis and data management. In addition, a digital voice recorder and camera were used to collect voice recordings and photos. Using these tools called for less formalised or structured instrumentation and placed more emphasis on the skill of the interviewer to encourage participants to elaborate on how and why they conduct their energy practices. The instruments used during the household tours ensured results could be comprehensive, comparable and securely stored.

4.5 Ethical considerations

Care was taken to ensure all participants were engaged ethically with the research and able to participate. The following steps were taken to ensure ethical transparency:

- Prior to face-to-face meetings, participants were asked about potential vulnerabilities (e.g. receiving hospitalisation for mental illness).
- Each participant was provided with an information sheet informing them of the nature of the research and the data protections in place to safeguard their anonymity and any data generated from involvement in the research.
- Coding data with numbers instead of names to protect the identity of participants.
- Using codes for identification of participants when transcribing audiotapes, and destroying the tapes on completion of the transcription.
- Storing data with any identifying information on an encrypted drive stored in a locked office to which only two persons have access.
- Disposing of information that can reveal the identity of participants or places carefully.

Prior to conducting the fieldwork, I also accessed and reviewed legislation under the Data Protection Act 2008.

[7] See Form Connect, http://www.formconnections.com/

Chapter 5: Results

5.0 Introduction

The results presented in this chapter illustrate some of the dynamic forms of co-residence that exist within UK households today. Some of the households in the case studies take a neat, static form. However, for a proportion, the household environment is more variable. There are fluid movements of predominantly family members in and out of the household. The timing of such movement can be unpredictable and unplanned. Some households find themselves in transition, for example, if a family member dies or becomes unwell. For others the timing may be predictable because of occurrences like the birth of a baby or a child leaving to attend university.

To illustrate the effects of household composition and changes in circumstances on electricity consumption, eight case studies are presented (for an explanation as to how the households were selected in the sample please refer to the methodology section 3.6.1). Each case offers a unique perspective in helping to understand the factors influencing patterns of domestic electricity consumption. The characteristics of the eight case studies are presented in the table below. The case studies are a collection of diverse households in relation to the number of people in each household, property type, occupation and income.

Table 5.0 Eight case studies: Summary of demographics

Interview ID	Name(s)	Property type	Number of people in household	Occupation	Household Income (£)
DL01	John & Mary	Detached	2	Retired	15,000-29,000
DL02	Tina	Flat	1	Retired	<29,999
DL03	Eve	Semi detached	3	Child minder	15,000-29,000
DL05	Heather	Mid terrace	3	Retired	<14,999
DL11	Nicola	Mid terrace	5	Mechanic	15,000-29,999
DL13	Sophie	Detached	4	Insurance Assessors	>29,999
DL15	Arthur	Detached	4	Retired	>29,999
DL17	Michael	End terrace	1	Lorry Driver	15,000-29,999

5.1 Case study metrics

At this stage it is useful to remind ourselves of the characteristics of the quantitative data used in this thesis to complement the qualitative data. Electricity consumption metrics were collected and analysed across each of the following three time bands to calculate total demand and particularly, electricity demand during the period of 4pm to 8pm; the time at which electricity load on the UK electrical grid is at its highest level:

- Band 1 8pm-8am
- Band 2 8am-4pm
- Band 3 4pm-8pm

Figure 5.1.1 below illustrates average (observed mean) electricity consumption over a 24 hour (hr.) period. 95% confidence interval (CI) testing has been applied to the observed means represented by the error bars in the chart.

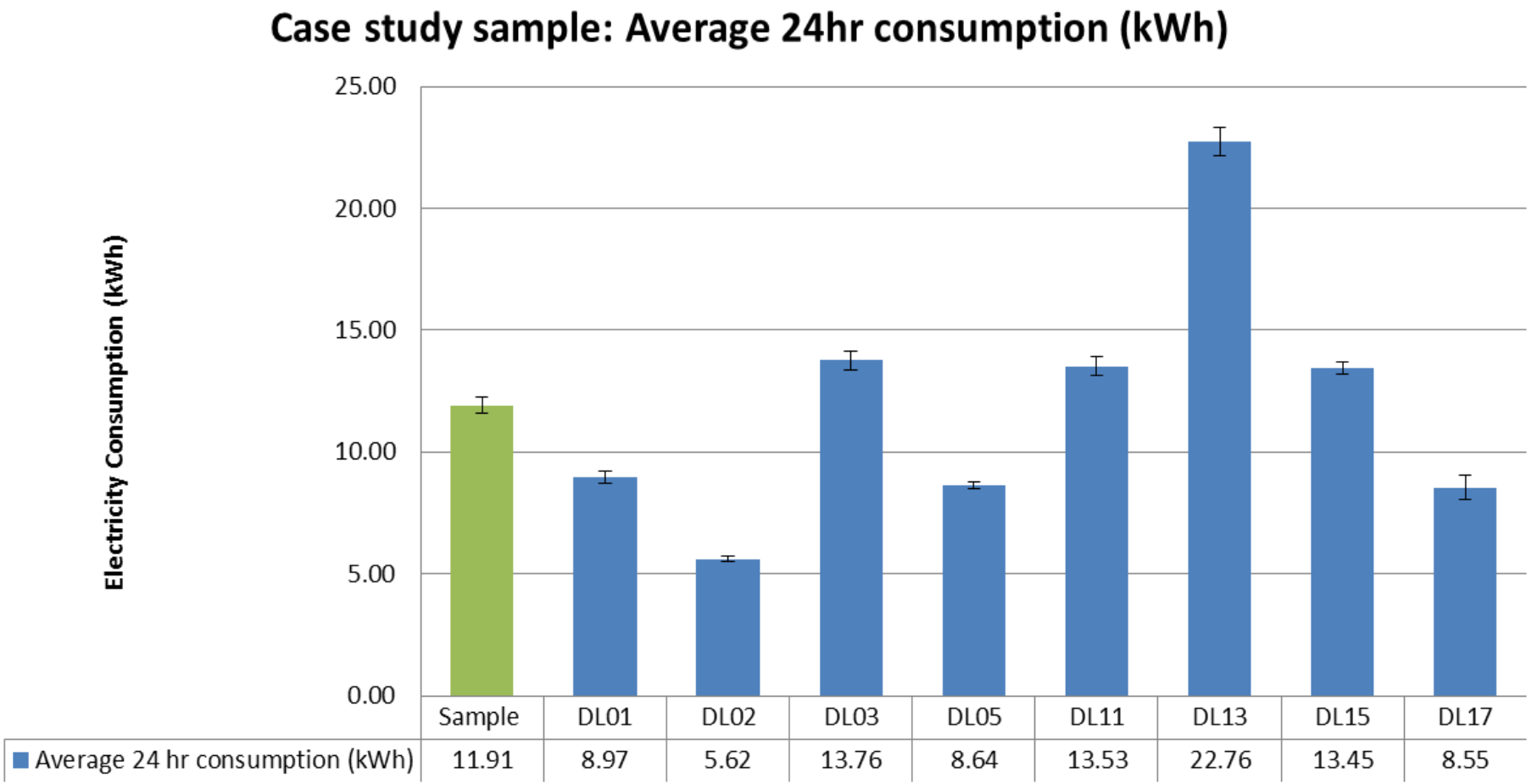
The average 24hr consumption (kWh) of electricity across the sample of eight case studies is 11.91 kWh ± 0.33 (SD=3.17) with a range in consumption from 5.62 kWh ± 0.13 (SD=1.3) (DL02) to 22.76 kWh ± 0.57 (SD=5.52) (DL13).

DL13 is consuming considerably higher levels of electricity over a 24hr period than any other in the sample, almost double that of the sample average 11.91 kWh. DL13 is a detached family household with four occupants. Given the average household in Great Britain consumes 11.16 kWh[8] over a 24hr period this level of consumption is high.

The confidence intervals illustrated on the error bars suggest two clusters of electricity use. DL03, DL11, and DL15, illustrate a similar level of electricity consumption over a 24hr period, consuming between 13.45 kWh to 13.76 kWh, each slightly above that of the sample average 11.91 kWh. This level of consumption makes these three households distinct from the other five households in the sample. DL01, DL05, and DL17, are consuming similar levels of electricity but notably less than the households above with 24hr consumption between 8.55 kWh and 8.97 kWh.

8 Department of Energy and Climate Change: Sub-national electricity sales and numbers of customers 2008-2011

Figure 5.1.1: Case study sample: Average 24hr electricity consumption (kWh)



5.2 Electricity consumption over three time bands

24hr electricity consumption was segmented into three periods. As a means of representing these periods of electricity use, the following three time bands are used:

- Average Day Time Electricity Use (AD, 8am -4pm)
- Average Evening Electricity Use (AE, 4pm-8pm)
- Average Night Time Electricity Use (AN, 8pm – 8am)

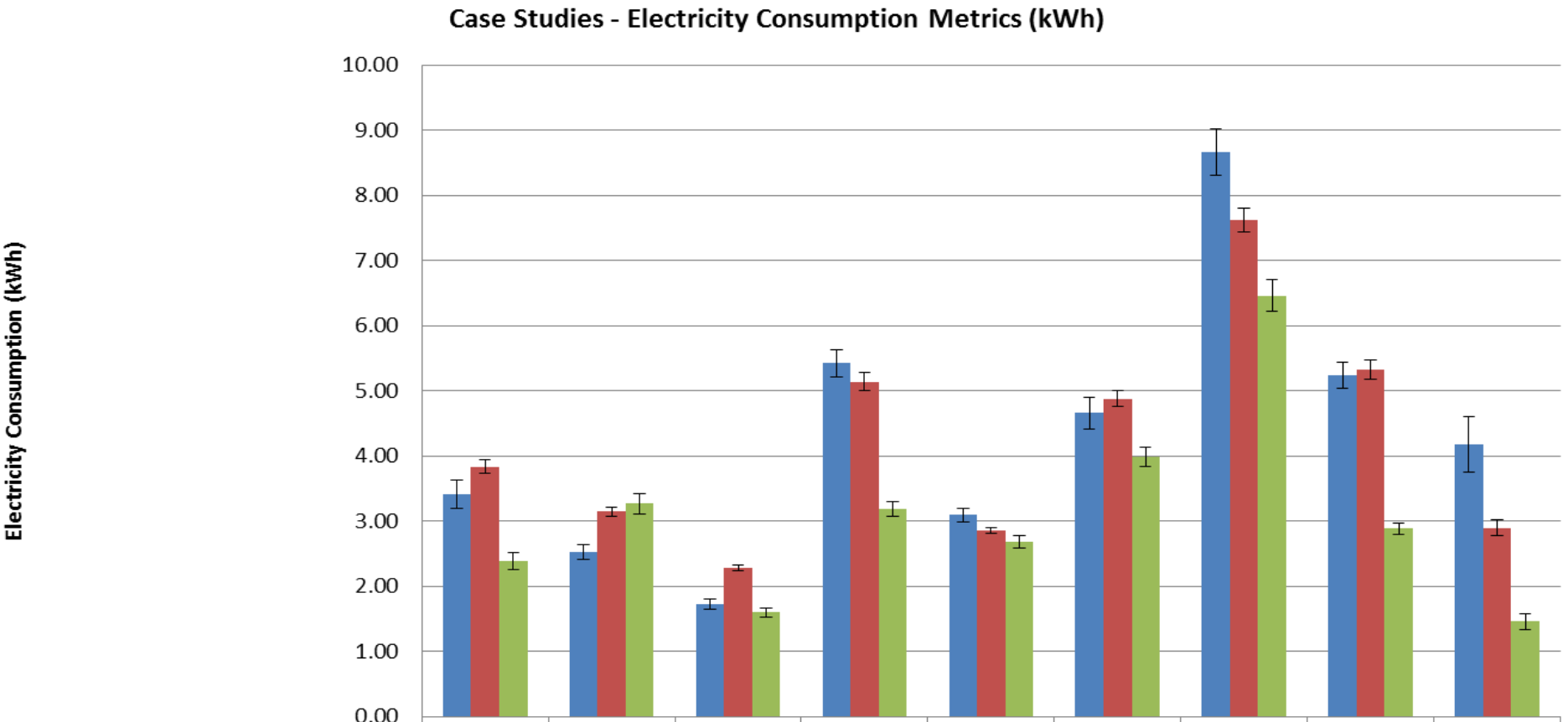
Table 5.2 below illustrates the range of electricity consumption levels (kWh) across the three time bands. DL02 consumes the lowest level during the day and night time. DL17 consumes the lowest during the evening period. During the day, DL13 consumes 2.5 times more electricity (kWh) than the sample average.

Table 5.2 Range of electricity consumption (kWh) across three time bands

	Lowest (kWh)	Highest (kWh)	Average (kWh)
AD 8am – 4pm	DL02 (1.72)	DL13 (8.67)	3.42
AE 4pm – 8pm	DL17 (1.47)	DL13 (6.47)	2.39
AN 8pm – 8am	DL02 (2.29)	DL13 (7.63)	3.84

Figure 5.2.1 below illustrates the pattern of consumption emerging for each case study across the sample. The different patterns between the case studies are intriguing. There is similarity between DL03, DL15, and DL17. DL02, DL15 and DL11 consume higher amounts of electricity (kWh) at night than at any other time over 24hrs. DL01 is the only household consuming more electricity (kWh) during the evening 4pm to 8pm period than at any other time over 24hrs.

Figure 5.2.1: Case study sample: Electricity Consumption Metrics (kWh)



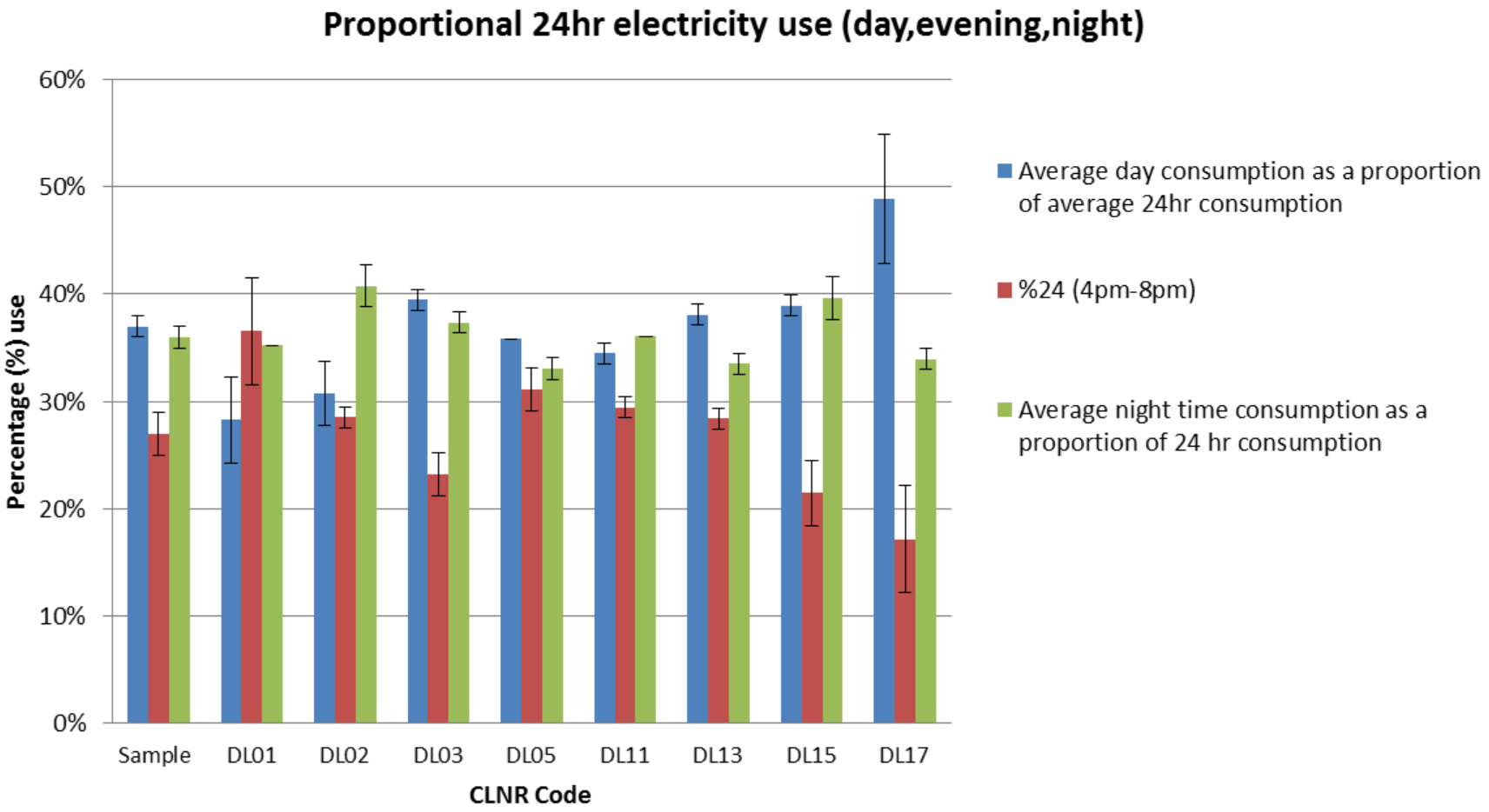
	Sample	DL01	DL02	DL03	DL05	DL11	DL13	DL15	DL17
Average Day Time (AD) (kWh)	3.42	2.53	1.72	5.43	3.10	4.66	8.67	5.24	4.18
Average Night Time (AN) (kWh)	3.84	3.15	2.29	5.14	2.86	4.88	7.63	5.33	2.90
Average Evening Consumption (AE) (kWh)	2.39	3.27	1.60	3.19	2.69	3.98	6.47	2.89	1.47

Figure 5.2.3 below illustrates the proportion of 24hr consumption split over the three time periods (day, evening and night). Once again, 95% confidence interval (CI) testing has been applied to the observed means represented by the error bars in the chart.

When consumption patterns are compared across the case studies, there is a striking difference in the proportion of evening consumption between DL17, 17% ± 0.05 (SD=0.07) and DL01, 37% ± 0.05 (SD=0.07). It appears a significant proportion (49%) ± 0.06 (SD=0.08) of DL17 electricity consumption (kWh) is occurring during the day. DL05 and DL11 illustrate similar patterns of electricity consumption over 24hrs.

The chart illustrates relative consistency amongst the sample in relation to the amount of electricity consumed during the night relative to other periods over 24hrs.

Figure 5.2.3 Case study sample: Proportion 24hr electricity use (day, evening, night):



5.3 Electricity Consumption Factors (:1)

As a means of analysing the extent to which household electricity demand is more intensive during certain periods, three consumption factors are calculated to represent the intensity of day, evening and night time consumption relative to other times over a 24hr period. (An explanation of each factor is provided in the methodology section 4.3.2).

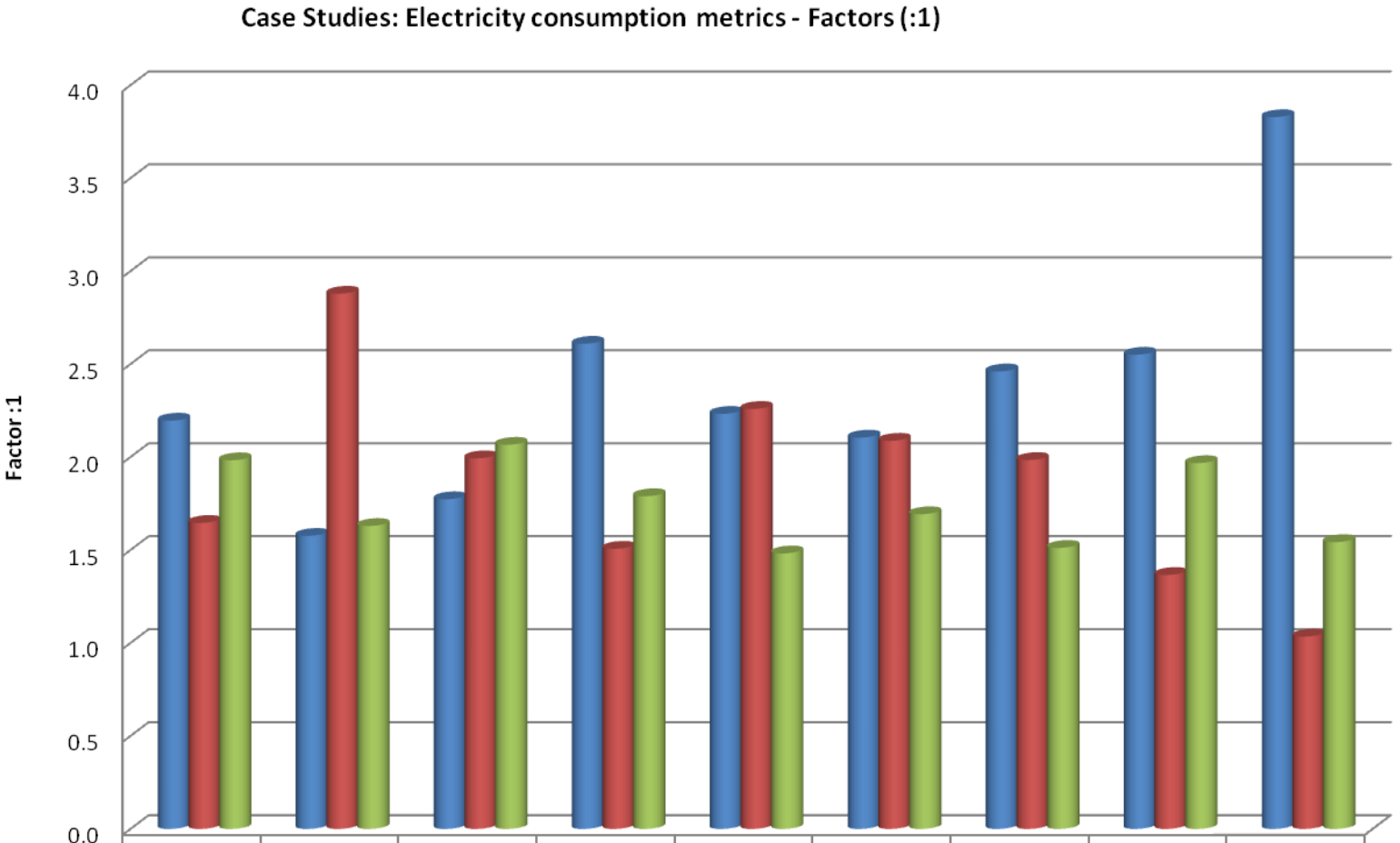
5.3.1 Consumption factor analysis: Observations

Figure 5.3.1 below illustrates that the average ratio for the sample is 1.8:1. DL01 consumed 2.9 times more electricity during the 4pm-8pm period than during the other twenty hours of the day; considerably more than the sample average. The pattern of consumption is considerably higher in comparison to DL17 with a ratio of 1:1, illustrating no change in electricity consumption during the 4pm-8pm period relative to other periods of the day.

With a daytime consumption factor of 3.8:1, DL17 consumes more electricity during the daytime relative to evening and night time consumption. Similarly, DL03, DL13 and DL15 consume higher amounts of electricity during the day relative to other periods.

DL01 and DL05 are the only cases in the sample consuming more electricity during the evening period relative to other periods of the day. Night time consumption is fairly consistent across the sample, with an average consumption factor of 2.0:1 and a range of 1.5:1, (DL01, DL05 and DL13) to 2.1:1, DL02.

Figure: 5.3.1 Case study sample: Electricity consumption metrics (day, evening, night)



	Sample	DL01	DL02	DL03	DL05	DL11	DL13	DL15	DL17
Day time consumption factor (DCF)	2.2	1.6	1.8	2.6	2.2	2.1	2.5	2.6	3.8
Evening Consumption Factor (ECF)	1.6	2.9	2.0	1.5	2.3	2.1	2.0	1.4	1.0
Night time consumption factor (NCF)	2.0	1.6	2.1	1.8	1.5	1.7	1.5	2.0	1.5

5.3.2 Quantitative analysis summary

So far, the quantitative results presented in this section have illustrated the variance in electricity consumption over 24hrs for the eight case studies. Data metrics from each case study have been presented to identify patterns in daytime, evening and night time electricity consumption. In the next section qualitative data captured during in house interviews is presented as we begin to understand the relationship between electricity consumption and the behavioural factors influencing 24hr patterns of electricity demand. A summary of quantitative electricity consumption metrics is also provided for each case study. The metrics provide an indication of the difference in daily electricity consumption across the eight case studies.

From now on the case studies e.g. DL01 will be referred to by their names e.g. John and Mary as we begin to learn more about the intricacies of their lives, evidence of fluidity and the role it plays in shaping electricity consumption.

5.4 Case study: Qualitative & quantitative results

A table is provided for each case study illustrating key characteristics including, interview ID, names, occupation of the householder being interviewed and other demographical information. Another table contains a summary of consumption metrics for each case study used to complement the qualitative data.

5.4.1 Case study 1 (John and Mary)

Table 5.4.1a Case study 1 (John and Mary): Profile

Case study 1	Profile
Interview ID	DL01
Name(s)	John & Mary
Occupation	Retired
Number of people	2
Household Income	15,000-29,000
Time in property	15
Age of property	1980s
Thermal efficiency	High
Tenure	Owner Occupier
Test Cell	1

Household (DL01) consists of retired couple John and Mary. John was interviewed alone. As part of the CLNR trial, John and Mary had a smart meter and IHD installed in their home.

John and Mary occupied the same house for fifteen years having purchased the property as their retirement home. John and Mary are an elderly couple, they have experienced decades of change in relation to domestic electricity use. During the interview John reflects upon the thermal performance of other properties he and Mary have lived in.

When we grew up we had an old fashioned range, the range heated the hot water at the same time.

When we got married things were getting more modern and we went for the combi [combination boiler].

When we first got married, we lived in a cottage and it was very cold upstairs, but it's lovely now to know it's going to be nice and warm upstairs when you go to bed. (John)

They had previously experienced periods of fluidity with the arrival of grandchildren. More recently, John has retired and Mary's health is faltering; each of these changing circumstances directly impacting the nature of routines and practice related to electricity consumption. At the time of interviewing, electricity consumption over a 24 hour period is determined by a series of routines e.g. cooking, clothes washing and bathing. John and Mary experimented shifting times by which

practices are conducted in the past, but find they naturally revert back to their normal pattern after a short period of change:

You mean cook earlier on in the day? I'm not sure the wife (laughs) tried that before but we usually revert back to the usual five o clock, six o clock routine so it's probably not worth trying to be flexible. (John)

Two years ago, John was forced to take early retirement due to a work-based injury to his leg and is still adjusting to non-working life. John is partially enjoying retirement, but a feeling of frustration was apparent from John in relation to it:

Well I was working up until two years ago you know. But I was forced into retirement coz I injured my leg a while back and it's taken a long time to mend.

I'm enjoying it [retirement] on and off (Laughs) (John)

In this household the kitchen is a key hub. John and Mary have all their meals in the kitchen area and in the evening they like to watch the six o'clock news together in the kitchen:

Well we have all our meals in here (kitchen)

Well we don't usually have our evening meal until about half past six/ seven o clock. We usually watch the six o clock news together when having dinner in the kitchen. (John)

Outside of meal times taking place in the kitchen, John and Mary often watch television in different areas. John is happy about this as he and his wife differ in what they like to watch on television. In this instance, two zones are active in their home:

She (wife) watches TV in here (kitchen) whilst ironing, I don't mind as I get to watch my telly in the living room. I don't like her programmes anyway! (John)

There is strong evidence of contestation around electricity use in the household; John's retirement resulting in him being at home frequently has, without doubt, exacerbated this. When referring to his wife, John smiles or laughs implying debates were not of a serious nature but rather a form of light-hearted entertainment; this is particularly prevalent in relation to lighting practices:

Do you know I once counted the number of lights we have in the house? She loves laps you see! (laughs)

I once counted and found there were 26 light bulbs present in the house…

Don't mention getting a dishwasher, (laughs) there's a great deal of controversy about getting a dishwasher. We've no space, nowhere to put it (John)

John perceives his wife Mary is the main consumer of electricity. John talking about the (electric) fire in the living room:

Wife plays hell because she likes the glow on the fire, you can have the glow without the fire on that one. I always tell her (laughs) I can't see the point in having the glow without the fire. (John)

John is concerned about energy bills rising, although he and Mary can adequately meet their fuel bills. He feels rising prices are making him more energy-conscious but, believes his wife is not so concerned about rising energy prices:

It's influenced me but doesn't influence the wife; she keeps on using as much as she likes don't matter about the cost.

We'll we can cover them (gas and electricity bills) no problem about that, but they do concern me that they keep going up. (John)

As part of their involvement in the trial, John and Mary had a smart meter and an in-home display (IHD) installed. John uses the IHD approximately three times per week and values the information it provides. Feedback implies Mary rarely uses the smart meter to inform her abut electricity consumption:

Well, it's alright, it's handy, gives you a view of how much you're using and what not. When it goes red I keep switching things off and wife puts them back on... (Laughs)

I use it (IHD) two three times per week, in winter I look at it regularly. The electric is a lot cheaper than the gas. (John)

At the time of the interview, electricity consumption patterns are largely attributed to Mary's practices and routines with John taking a passive role in relation to cooking, washing and ironing. However, this division of labour is precarious as Mary's health is deteriorating:

Majority of time she puts the washing on in the morning.

She's not been too well as of late you know. (John)

In future, if Mary is no longer in a position to conduct household chores due to ill health, John may be forced to fill this void. It is unknown whether the same consumption pattern or ratios will apply.

With an evening (4pm-8pm) consumption factor (ECF) of 2.9:1 John and Mary consume the largest amount of electricity during this time than at any other period of the day. Over a third of John and Mary's 24 hour electricity consumption is consumed during this period. Feedback from John suggests this consumption is attributed to cooking, lighting and entertainment; all of which are routine with little potential for change.

John and Mary go to bed between twelve and one o'clock, late evenings are spent watching television or talking amongst themselves. Lighting and electrical appliances such as their television are still active late at night until the early hours of the morning increasing electricity consumption in the evening 4pm-8pm and overall 24 hour consumption:

We are usually late to bed for whatever reason, it can be twelve or one o clock in the morning, we usually watch a film or just sit up talking. (John)

Table 5.4.1b Consumption Metrics – Case study 1: John and Mary

Case Study 1: Consumption Metrics					
	Average 24 hr consumption (kWh)	Average Day Time (AD) (kWh)	Average Night Time (AN) (kWh)	Average Evening consumption Time (AE) (kWh)	24% (4pm-8pm) % / Evening Consumption Factor (ECF)
Sample	11.91	4.44	4.27	3.19	25 / 1.8:1
DL01	**8.97**	**2.53**	**3.15**	**3.27**	36 / 2.9:1
Standard deviation (DL01)	*2.34*	*1.11*	*0.73*	*1.55*	
Difference (Sample Vs DL01)	-2.94	-1.91	-1.12	0.08	14 / 1.1:1

Case Study 1 (John & Mary) Consumption Metrics – Observations

The average 24 hour electricity consumption 8.97kWh is lower than the sample average 11.91kWh, John and Mary are both retired and often at home during the day.

Examining the consumption metrics in further detail reveals that in comparison to the sample average 4.44kWh, this household is consuming a relatively low amount of electricity, 2.53kWh, during the daytime period. John and Mary don't have a cooked lunch nor do they use their electric shower during the day as they prefer baths, both factors are lowering their overall electricity consumption during this period.

With 36% electricity consumption 3.27kWh occurring during the evening period (4pm-8pm), daily consumption of electricity is at its highest level during this period and notably higher than the sample average 25% 3.19kWh. John and Mary also had the highest evening consumption factor in the sample 2.9:1. John and Mary are usually present during these periods carrying out practices such as cooking and clothes washing. The evening period is a time when lights would be switched on within the home, particularly during the winter periods. Mary likes to use lamps instead of main lights undoubtedly this behaviour is contributing to the evening consumption pattern.

Case Study 1 (John & Mary) Summary

John and Mary are retired and live in a modern three bedroom semi-detached house. Although John and Mary have experimented with changing the times when practices such as cooking or bathing are performed, many of their electricity consumption practices have become routine with limited potential for flexibility, unless a change of circumstance forced a change in practice.

There is strong evidence of contestation around energy use within this household, no doubt exacerbated by John being home more often due to his retirement thus increasing the likelihood of him being present to observe Mary's behaviour in relation to electricity consumption.

At present, Mary is the main consumer of electricity performing many domestic chores such as ironing, clothes washing and cooking with John taking a passive role. However, this trend is starting to change. Unfortunately, as Mary's health is deteriorating, John is forced to play a more active role in the domestic chores. It is unknown whether John will conduct practices previously undertaken by Mary in the same way, therefore when and how practices such as cooking, ironing and clothes washing take place will change; altering patterns found in the electricity metrics for this household.

5.4.2 Case Study 2 DL02 (Tina)

Table 5.4.2a Case study 2 (Tina): Profile

Case study 2: Profile	Profile
Interview ID	DL02
Names(s)	Tina
Occupation	Retired
Number of people	1
Household Income	< 29,999
Time in property	5
Region	Low Thermal Efficiency
Age of property	11
Thermal efficiency	Medium
Tenure	Private Rented
Test cell	1

DL02 (Tina) lives in a small two bedroom flat she has rented for approximately five years following the death of her mother. The consumption metrics illustrate Tina is consuming the lowest level of electricity of all the cases in the sample.

Tina has never married and had lived in another dwelling with her mother until she passed away five years ago. Tina's mother used to perform domestic practices such as cooking, washing and ironing and Tina is still adjusting to life without her mother. Tina's pattern of electricity consumption is, in part, determined by her health condition which varies daily depending on how she is feeling. For example, if Tina is feeling aches and pains she will opt to go to bed early and watch television from her bedroom:

I often watch television late at night in bed rather than stay up, particularly if it's a bad day you know, with my condition and that. (Tina)

Where Tina consciously chooses to abstain from practices such as showering in her wet room, or relaxing in her living room, these areas are effectively shut down:

If I'm particularly stiff it could be four o' clock in the afternoon before I have a shower

I might only have a shower one day then miss two or three days, my arms hurt drying myself you see so I need to give them a rest. (Tina)

A strong sense of resilience and independence emerged from this interview. At the time of interviewing a stair lift had been installed to the entrance staircase in Tina's flat. For now, Tina is resisting use of the stair lift:

They installed that stair lift but I try not to use it to be honest, I don't want to become reliant on it so I only use it if I'm having a bad day. (Tina)

The smell of food being cooked is something Tina dislikes greatly and she goes to great lengths to avoid it. Tina purchases sealed ready meals and cooks them in the oven, taking the view pre-packed ready meals are less likely to omit smells during the cooking process due to their packaging:

I must be perfectly honest, I don't cook every day. Purely and simply because if I smell something cooking I can't eat it! (Tina)

Although ready meals are *typically* cooked using a microwave, Tina prefers the taste when they are cooked in the oven. It is striking that both smell and taste of food directly impacts how Tina conducts her cooking practices. This factor directly influences Tina's pattern and level of evening electricity consumption:

That's a double oven. To be honest the main oven only goes on about twice a year, maybe once at Christmas. (Tina)

If I do cook something it's usually a ready meal. I cook it in the oven; I don't have a microwave.

I had a microwave when they first came out and I didn't like it. I don't like defrosting food using them as it starts to cook the food and it's awful! (Tina)

Tina washes clothes by hand as she does not own a washing machine due to a lack of space in her kitchen. Tina is not familiar with washing clothes as her mother used to wash all her daughter's clothes up until her recent death. Tina is anxious about undertaking this practice but expects to purchase a washing machine in future when she makes more space for one in her kitchen. For now, Tina relies on neighbours to wash big items e.g. bedding:

I don't have a washing machine I have no space in this moment in time. My freezer is in the place where the washing machine would go.

Of course there is going to come a time where I'll get a fridge freezer; then I'll get a washing machine (Tina)

Table 5.4.2b Consumption metrics – Case Study 2: Tina

Case Study 2: Consumption Metrics					
	Average 24 hr consumption (kWh)	Average Day Time (AD) (kWh)	Average Night Time (AN) (kWh)	Average Evening Consumption (AE) (kWh)	24% (4pm-8pm) / Evening Consumption Factor
Sample	11.91	4.44	4.27	3.19	25 / 1.8:1
DL02	**5.62**	**1.72**	**2.29**	**1.60**	**29 / 2:1**
Standard deviation (DL02)	1.30	0.76	0.36	0.73	-
Difference (Sample Vs DL02)	-6.29	-2.72	-1.98	-1.59	4/ 0.3:1

The average 24hr electricity consumption 5.62 (kWh) is the lowest electricity consumption of all the case studies presented. The property is a small two bedroom private rented flat occupied by one person (Tina) therefore, the low level of consumption is not surprising.

Examining the consumption metrics in further detail reveals in comparison to the sample average 4.44kWh, this household is consuming low levels of electricity 1.72kWh during the daytime period. If her health is good enough, Tina likes to go out shopping locally during the day. Again this helps to explain the low level of electricity consumption during this period.

With an evening consumption factor (ECF) of 2:1 and 29% of daily consumption taking place during the evening period 4pm-8pm, consumption of electricity is at its highest level during this period. The consumption pattern implies Tina is often at home using appliances such as the cooker, television and lighting during the evening period.

Case study 2 (Tina) Summary

Tina lives alone in a two bedroom rented flat. Tina is a good example as to how fluidity in health status can impact upon electricity consumption. Tina's health is a major factor in determining her daily pattern of electricity consumption. If Tina is feeling unwell she will choose not to shower or

leave her home to go shopping, she may also opt to go to bed early in the evening and watch television in her bedroom. Living alone means Tina has full control over her daily electricity practices. Some of Tina's behaviours are unorthodox particularly her displeasure at the smell of food cooking and her choice not to have a washing machine; both uncommon trends from a UK domestic context but are shaping her daily electricity profile. Tina is finding it difficult to adjust without her mother. When Tina's mother was alive she would lead on domestic chores such as clothes washing, ironing and cooking. Although Tina's mother passed away five years ago, she is yet to purchase a washing machine for her flat, preferring to wash clothes by hand or rely on assistance from neighbours.

5.4.3 Case Study 3 [DL03 (Eve) Interview]

Table 5.4.3a DL03 (Eve): Profile

Case study 3	Profile
Interview ID	**DL03**
Name(s)	Eve
Occupation	Child Minder
Number of people	3
Household Income	15,000-29,999
Region	York's & Humber
Age of property	1999
Thermal efficiency	High
Tenure	Owner Occupier
Test cell	1

DL03 (Eve) consists of a family household of three, mother, partner and son. The mother (Eve) was interviewed alone.

Eve's family has occupied the same house for 25 years: a daughter moved away two years ago. The house was extended to three bedrooms when Eve's son was born. Eve's daughter used the additional bedroom and on her moving out it was transformed into a playroom for the children Eve cares for as a home-based childminder. At the time of the interview her partner is unemployed.

Eve's son is planning on moving away to university at which time Eve expects to see a reduction in household fuel bills. At the time of the interview, the household is experiencing financial strain as the level of caseload in Eve's childminding business has fallen.

Many of Eve's routines and accompanying energy practices are woven around her son's school day and her child minding duties:

I get up at seven to get my son up for school. I just have a coffee for breakfast; lunch I have about twelve. We are both in during the day and kids are back around half past three so it's all a bit mad about then.

Breakfast time it's just cereal, toast. They (the children) normally sit down to eat about half four, half past four. We get them fed and off home about half five six then I would probably eat about seven. (Eve)

These routines have the effect of discouraging Eve from doing laundry in the peak period. Instead she washes clothes in the early morning or evening:

I don't wash during 4pm-8pm as I'm busy feeding and packing off the kids. We wouldn't change the way we do things really. I wash in morning and late at night before I go to bed so...I don't think I would change that... (Eve)

Eve stated her propensity to put a clothes wash on is dependent on weather conditions because she prefers to air dry the laundry outdoors:

I put a wash on around seven when I get up. Then I put another one on during evening before I go to bed, coz its cheaper then isn't it? My washing is weather dependent, if it's a dull day I won't bother, but if it's a bright warm day I'll get a wash on first thing. (Eve)

Eve has fewer children to mind than was previously the case in part attributed to the recession and other changes in her clients' circumstances:

I have seven kids on my books but none during the day today, I'll pick up three from school later on. I used to look after more but I've had a few fall-off-the-books; people are cutting back coz of the recession.

One of the little boys I used to keep overnight now and again but his sister is sixteen now and she's old enough to look after him. (Eve)

The childminding business means that the household needs to run two freezers to accommodate food and a television is provided in their playroom. There are a total of four televisions in the house, two upstairs and two downstairs, three of which are in working order:

I like different television if I'm watching The Voice and he wants to watch the footy he gets shifted upstairs. He's not very happy about it! (Eve)

Eve's son is perceived as the main consumer of electricity in the household. Eve's reasoning for this is attributed to the number of appliances in his bedroom:

My son's got loads of electric stuff, he's just bought a Mac he's got a Wii and Xbox and a laptop too. As soon as he gets in at three o' clock he's straight upstairs onto the laptop... (Laughs) (Eve)

Eve's son also showers daily as does her husband while Eve prefers a bath before bed:

I like to relax at the end of the day". (Eve)

Eve prefers lamps and candles to create a relaxing environment in the evening:

They don't take low energy bulbs, I light candles on an evening and we tend to use the glow from the fish tank... (Eve)

As part of the CLNR trial the household had been given a smart meter with an In-Home Display (IHD) unit which Eve has taken to consulting daily to check the household's expenditure on electricity, focusing on cost rather than kWh consumed. She is particularly motivated to do so because she recently stopped paying her bill by Direct Debit:

I do like to keep an eye on it. I was paying £174 per month for gas and electric but with him (partner) not working and having fewer kids on the books I cancelled the direct debit, so I just pay what I can when I can now. I think we're on top of it.

I've been checking the smart meter, I checked it yesterday. I used one pound seventy something yesterday (Laughs) I probably look at it once a day, am just interested in looking at it really to see how much I'm using then I know how much I owe at the end of the month. (Eve)

Eve expects her fuel bills to reduce when her son heads off to university:

As soon as my son goes off to university in September with all his stuff; bills should come down then. (Eve)

5.4.3b Consumption metrics - Case study 3: Eve

Case Study 3: Consumption Metrics					
	Average 24 hr consumption (kWh)	Average Day Time (AD) (kWh)	Average Night Time (AN) (kWh)	Average Peak Time (AE) (kWh)	24% (4pm-8pm) / Evening Consumption Factor
Sample	11.91	4.44	4.27	3.19	25 / 1.8:1
DL03	**13.76**	**5.43**	**5.14**	**3.19**	**23 / 1.5:1**
Standard deviation (DL03)	*3.62*	*2.03*	*1.38*	*1.12*	-
Difference (Sample Vs DL03)	1.85	0.99	0.87	0.00	-2 / -0.3:1

The average 24hr electricity consumption 13.76kWh is higher than the sample average of 11.91kWh. At the time of the interview Eve and her partner are predominantly present in the household during

the day and her son is also living in the household which may explain the higher level of consumption.

Examining the consumption metrics in further detail reveals in comparison to the sample average 4.44kWh, this household consumes higher levels of electricity 5.43kWh during the daytime period. Eve's partner is unemployed and she is running her child-minding business from the home, which helps to explain the higher than average consumption pattern.

With 23% of electricity consumption 3.19kWh occurring during the evening period (4pm-8pm) and an evening consumption factor (ECF) 1.5:1, evening consumption is not significantly higher during this period in comparison to other periods during the day. Average night time (AN) consumption 5.14kWh is higher than the sample average of 4.27kWh. This is because Eve's partner and her son like to stay up late into the early hours of the morning and are typically using appliances or devices during this time.

Case study 3 (Eve) Summary

Eve working from her home as a child minder is central to how and when energy-related practices are performed particularly during the day and early evening period. Eve's partner is currently unemployed (eight months) and is present during the day which results in additional electrical load being used. Eve's own child-minding caseload has also reduced as a result of the recession and changes in relation to the ages of the children she cares for.

Eve's household is a good illustration of how a household's energy consumption fluctuates over longer and shorter periods of time with implications for consumption patterns and potential for flexibility in times of use. The household composition was relatively stable at four permanent occupants for twenty years. Extra pressure was put on energy consumption as Eve took up her childminding. Although the extra consumption from childminding activities might have been mitigated by Eve's partner being in employment and out of the house during working hours. Later he finds himself unemployed and at home during the day, the daughter is no longer a member of the household and the childminding activity has curtailed. There were no children at the house on the day of the interview. However, Tina's son continues to use appliances intensively. Energy bills are currently causing anxiety and Eve takes consolation from the fact that her son's appliances and his daily showers will soon be powered from outside the home at least during university terms. It is impossible to predict the future but this household's energy consumption patterns are likely to continue to undergo fluctuations. Eve's son will return during university holidays for three years and the child-minding business may pick up beyond recession whilst Eve's partner may also become

employed. The current incidence of children returning to live with parents on a permanent or temporary basis suggests that with two adult children in the family, fluidity may never be too far away.

5.4.4 Case Study 5 [DL05 (Heather) Interview]

Table 5.4.4a Case study 4 (Heather): Profile

Case Study 4	Profile
Interview ID	DL05
Name(s)	Heather
Occupation	Retired
Number of people	3 (2 Older Sons)
Household Income	< 14,999
Region	York's & Humber
Age of property	1930s
Thermal efficiency	Medium
Tenure	Owner Occupier
Test cell	1

DL05 (Heather) has lived in this household since marriage approximately fifty years ago. Heather's husband died eight years ago and she now shares her home with her two adult sons:

I've lived here nearly 50 years, this was my married home. I lost my husband twenty years ago.

I have the two boys (41) and (43) the younger one has moved out twice and come back (Laughs) (Heather)

Heather is central to energy consumption in this household and is busy daily performing chores such as laundry, cleaning and cooking:

Although the consumption metrics illustrate a fairly consistent level of electricity consumption over a 24hr period; timings and routines are shaped by Heather around the needs of her two sons. Heather performs these chores around her sons' working patterns; particularly evidenced in relation to cooking as Heather prepares cooked meals for her *'boys'* returning from work around 5pm in the evening:

I cook about four o' clock in time for the boys coming home at five. They like a cooked meal. I do this every day, only time off (Laughs) I get is at the weekend when they go to take away at the bottom of the road. (Heather)

All cooking is performed using electric, this helps to explain the Evening Consumption Factor (ECF) 2.3:1 during the 4pm-8pm period with 31% of daily electricity consumption being used during these times.

Heather could recall using coal and refused to covert to gas when it was installed in her neighbourhood during the 1970s; deciding instead to cook using electricity, with which she was familiar:

When we got married we used to cook on coal, then the gas was installed, but we decided to stick with my electric hob and oven. I'm used to it you see, I've always cooked using the electric.

Even when the pits closed, I stuck to my fire, I used the smokeless coal for a bit when they came round with that, but then it got too bad (mobility) making up the fire every day because my knees got bad so we changed it to gas. (Heather)

Heather has experienced decades of change in relation to energy use but when it comes to adopting new technologies Heather is a laggard. The house was heated using smokeless coal but this system was upgraded to a high efficiency gas condensing system as Heather has begun to experience difficulties with mobility and could no longer manage heavy coal:

We used to heat the living room using the coal fire, it had a back boiler on it too that used to heat the water, that (the fire) is now gas; we had a gas boiler installed eight years ago.

Even when the pits closed, I stuck to my fire, I used the smokeless coal for a bit when they came round with that, but then it got too bad (mobility) making up the fire every day because my knees got bad so we changed it to gas. (Heather)

The presence of a 1970s spin dryer and early 1980s cooker in her kitchen is further evidence Heather has been reluctant to adopt new technologies.

Heather does laundry in the morning. One issue restricting flexibility around this practice is the fact Heather likes to be home when her washing machine is in use. Heather recites a friend whose washing machine flooded when it was left unattended and as a result, Heather never leaves her washing machine unattended:

I put washing machine on in mornings when I get up but sometimes I'll put it on after evening dinner if the boys need something in. (Heather)

I don't like leaving it on while am out, my friend did that once and it (washing machine) flooded her whole house. I don't wasn't it to catch fire either… (Heather)

Heather's sons take part in electric toy car racing, making use of a local 'pit top.' Heather's sons charge the electric cars in her living room in between use:

My sons have these electric racing cars; they go out on 'pit top' on a weekend racing them. The younger one stops in a lot but the older one likes doing that, he works on a farm you see so he's always out and about.

They often charge the cars when they aren't out with them (Heather)

As part of the trial, Heather was provided with a smart meter and in-home display (IHD). Heather does look at her IHD in-home display from time to time but it isn't something she used to inform electricity use daily. Heather is aware when the red light is illuminated it means she is using high levels of electricity:

It's always plugged in but, no, I don't really look at it, I don't really take much notice of it (IHD in home display).

When it goes red I know I'm using a lot of electricity, tends to be on evening when am cooking. (Heather)

Table 5.4.4b Consumption metrics - Case study 4: Heather

Case Study 4: Consumption Metrics					
	Average 24 hr consumption (kWh)	Average Day Time (AD) (kWh)	Average Night Time (AN) (kWh)	Average Peak Time (AE) (kWh)	24% (4pm-8pm) / Evening Consumption Factor
Sample	11.91	4.44	4.27	3.19	25 / 1.8:1
DL05	**8.64**	**3.10**	**2.86**	**2.69**	**31 / 2.3:1**
Standard deviation (DL05)	*1.48*	*1.02*	*0.37*	*0.87*	-
Difference (Sample Vs DL05)	-3.27	-1.34	-1.41	-0.50	6 / 0.5:1

The average 24hr electricity consumption 8.64kWh is notably below the sample average of 11.91kWh this is surprising given Heather has two adult sons living in co residence. Examining the consumption metrics in further detail reveals in comparison to the sample average 4.44kWh, this household is consuming a relatively low amount of electricity 2.53kWh during the daytime period. Heather often goes out during the day shopping or taking part in social activities whilst Heather's sons are at work during the day, returning in the evening around 5pm.

With 31% of electricity consumption 2.69kWh occurring during the evening period (4pm-8pm) and an evening consumption factor (ECF) of 2.3:1, electricity consumption is at its highest level during this period relative to other hours of the day. This is a time when Heather is preparing meals for her two sons using her electric cooker and at times her microwave; all occupants are typically present during this time.

Case study 5 (Heather) Summary

Heather is central to energy consumption in this household and is busy daily performing chores such as laundry (washing and drying), cleaning and cooking. Although the consumption metrics illustrate a fairly consistent level of electricity consumption over the 24hr period, timings and routines evidenced suggest Heather performs these chores around her sons' working patterns; particularly evidenced in relation to cooking as Heather prepares cooked meals for her sons returning from work around 5pm in the evening. As all cooking is performed using electric, this helps to explain the trend found in the consumption metrics; Heather's household has an Evening Consumption Factor (ECF) 2.3:1 during the 4pm-8pm period with 31% of daily electricity consumption being used during these periods.

Heather has experienced decades of change in relation to energy use but when it comes to adopting new technologies Heather is a laggard; Heather's heating system was only recently upgraded to a modern gas condensing system. The presence of a 1970s spin dryer and early 1980s cooker in her kitchen is further evidence heather is a laggard in the adoption of new technologies.

Heather co-resides with her two adult sons, one of which has moved away twice but returned back to his mother's home on both occasions. The circumstance of Heathers sons' return was not investigated during this interview, but their presence means the dynamics within this household are volatile. Either or both son(s) could move out at any time. If this occurred, Heather may conduct domestic chores e.g. cooking, clothes washing at different times as she is no longer restricted by the need to fit in with her sons' working patterns.

5.4.5 Case Study 5 [DL11 (Nicola) Interview]

Table 5.4.5a Case study 5 (Nicola): Profile

Case study 5	Profile
Interview ID	DL11
Name(s)	Nicola
Occupation	Mechanic / Housewife
Number of people	5 (2 adults 3 Children)
Household Income	15,995-29,999
Time in property	16
Region	York's & Humber
Age of property	1900s
Thermal efficiency	Low Thermal Efficiency
Tenure	Owner Occupier
Test cell	1

DL11 (Nicola), electricity consumption in this household is fairly consistent during the day time and evening period. Nicola is central to electricity consumption within the home conducting most chores particularly cooking and washing. Three young boys reside in this household and Nicola's daily routines in relation to domestic chores are structured around the demands of her three children:

We have three boys you see so everything (domestic chores) is done round them

During the week, routines such as cooking, showering and washing are performed to fit in with the demands and schedules of schooling:

I usually, cook around half four five, the boys come in from school; they have their TV and games time whilst I cook.

It's all gas used to cook apart from the microwave. Its electricity your after isn't it?

I usually put a wash on in the evening about five o clock, usually its one load per day; their school stuff and my work clothes.

With the three boys, there's lots of football so lots of washing (laughs).

Sometimes on a weekend I might do a wash in the morning, but it's usually done around five during the week, I like to get it out of the way. (Nicola)

Although the structured regimes of schooling provide limited opportunity for flexibility in relation to electricity use there is potential to reduce electricity consumption during the 4pm to 8pm period. All three children share a keen interest in games consoles, each possessing their own console and television to reduce conflict:

It stops them from arguing all the time it's just less hassle that way, they don't argue about what games to play.

Yes, we have three X Boxes in this house, it's all upstairs, we have four televisions, one down here three upstairs, they have them to play on the XBox.

If they're in all four televisions are on the go with the Xboxes'!

The twins play on their XBox upstairs and the young one uses the telly down here (Nicola)

Each console is in use during peak hours 4pm-8pm; as the children grow older and develop independent interests this behaviour will change. Entering into secondary school will bring with it new hobbies and interests.

Although the consumption metrics illustrate this household is using more than the average for the sample, Nicola doesn't feel her electricity bills are too high:

I think our energy costs are about typical. I don't feel they are really high. I know they've gone up.

I was expecting bigger bills after the cold winter; they were big but not as big as I thought (Nicola)

Nicola has not used the smart meter in-home display (IHD) for some time as she perceives it as an annoyance. The IHD has not helped this household to manage its electricity consumption; although it was used for a short period, not long enough to have any sustained impact on electricity use:

Ah yes I do have the monitor in the cupboard, it was a good toy originally but the base thing it sits on kept falling off.

The kids used to turn the kettle on just to see it go red (Laughs)

We used it quite a lot at first to compare it to the bills when they came in to check they were accurate. Was quite good really!

I ended up putting it in a drawer about six months ago and that's where it's been since. It kept on falling off the plastic thing it sits on so became annoying.

Now it's in the cupboard, so sorry. (Laughs) (Nicola)

Nicola didn't rule out using the IHD in future if she considers her bills to be increasing:

Not really bothered about it. But if I wanted to get my bills down it might be used again. At the moment I don't think they're too high. (Nicola)

Nicola prefers to wash clothes during the evening period as she believes this '*gets it out of the way',* any offer from an energy supplier to reward a shift in timing would have to be generous to persuade her to change her behaviour:

I don't think I would change really, I suppose it depends, if it was a lot cheaper I would consider it. (Nicola)

Nicola's husband has a keen interest in motor bikes and frequently works on them in the garage. Nicola is happy about her husband's interests as it opens up space for her to conduct her household chores and watch whatever she likes on television:

My husband uses the garage, he rebuilds motor bikes, there's only a light and plug point in there, but he's in there quite a lot.

I don't mind him doing that, it keeps him out of the house and it means I can get on with my chores and watch what I want on TV. (Nicola)

Nicola and her husband have considered installing solar photovoltaic (PV) but were put off due to the capital cost of the equipment:

Actually, solar panels are something we are really interested in, it's just the cost of installing it.

I wish you didn't have to pay to have them installed cos it's (Solar PV) so expensive. (Nicola)

Table 5.4.5b Consumption metrics - Case study 5: Nicola

Case Study 5: Consumption Metrics					
	Average 24 hr consumption (kWh)	Average Day Time (AD) (kWh)	Average Night Time (AN) (kWh)	Average Peak Time (AE) (kWh)	24% (4pm-8pm) % / Evening Consumption Factor
Sample	11.91	4.44	4.27	3.19	25 / 1.8:1
DL11	**13.53**	**4.66**	**4.88**	**3.98**	**29 /2.1:1**
Standard deviation (DL11)	*3.60*	*2.37*	*1.19*	*1.49*	-
Difference (Sample Vs DL11)	1.62	0.22	0.61	0.79	4 / 0.3:1

The average 24hr electricity consumption 13.53kWh is higher than the sample average of 11.91kWh. Nicola, her husband and three children are living in the household so it is not surprising consumption is higher than the sample average.

Examining the consumption metrics in further detail reveals in comparison to the sample average 4.44kWh, this household is consuming a marginally higher amount of electricity 4.66kWh during the daytime period. Although Nicola's children are likely to be at school, this level of consumption implies one or both parents are present during the day.

With 29% of electricity consumption 3.98kWh occurring during the evening period (4pm-8pm) and an evening consumption factor (ECF) 2.1:1, evening consumption is high but not surprising given young children are certain to be home during this period with one or both adults present.

The average night time consumption 4.88kWh is higher than the sample average of 4.27kWh. This would imply occupants are staying up late into the early hours of the morning using appliances or devices.

Case study 5 Nicola summary:

Nicola's household is an example of a young family household structuring its electricity use to fit in with the needs of three young children. During the week, timings and thresholds in relation to electricity consumption are designed to fit around the needs of schooling. Meal times typically take place between 4pm to 6pm and whilst Nicola is making dinner the tree boys enjoy their after-school

play time, each using consoles to entertain themselves. 29% of 24hr consumption is being used during the evening 4pm to 8pm period with entertainment, meal times and showering taking place. Nicola does not feel her electricity bills are exceptionally high and points to her children as the main source of electricity consumption within the home. Each son has access to his own xbox entertainment system and television. Nicola and her husband feel it is best to keep the boys separated whilst playing on their Xboxes as it helps to reduce conflict and contestation within the household. Using the systems in this way undoubtedly adds to their overall 24hr electricity consumption. Nicola and her husband are interested in installing solar PV on their property but have been put off due to the high costs of installation.

5.4.6 Case Study 6 [DL13 (Sophie) Interview]

Table 5.4.6a Case study 6 (Sophie): Profile

Case study 6	Profile
Interview ID	DL13
Name	Sophie
Occupation	Insurance Assessors
Number of people	4
Household Income	>30,000
Time in property	25
Age of property	1970s
Thermal efficiency	High
Tenure	Owner Occupier
Test Cell	20 (Solar monitoring)

DL13 (Sophie) consists of a household with two adults, one teenager (sixteen) and an adult in co-residence. The interview was conducted with Sophie.

All occupants work shift patterns, they are rarely at home together at once. Sophie and her husband use the home as a place of work during the day and there are many appliances switched on constantly:

We both work from home as insurance assessors you see so we need all this stuff. [Sophie lists electrical equipment] We've got are 3 printers, 2 videos, the router and 2 splitters which are powered, a shredder, 5 computers, 3 towers and 2 laptops. One doesn't get used but the others get used all the time...O yes and an iPad.

My son, he's got a TV (Laughs). (Sophie)

The household recently installed solar PV as part of the CLNR trial; monitoring equipment had been installed to monitor generation and on-site use of electricity. The decision to install solar PV was led by her husband's persistency; Sophie feels it was a good investment due to the returns generated by the feed-in tariff:

My husband bugged me to death to get it in. In a way good job he did; the tariff was 43.3p I think, we managed to get installed before it (tariff) went down. (Sophie)

Wherever possible, Sophie states the household aims to use the electricity generated by the solar PV rather than exporting it back to the electricity grid. Sophie adapted her own behaviour to ensure this:

We don't want to export. We want to use. ... We are better off using it. That's why we then changed to that habit because we're using what we generate. We could change our habits more really, if we thought about it. Probably.

That's with my computer still on; everything else is on stand-by. If we're generating electricity – we try to use all of it! (Sophie)

Sophie changed her washing routines since solar photovoltaic panels were installed. Sophie used to wash clothes through the night, but now opts to wash during the day; taking advantage of the electricity being generated by the solar PV. Sophie will often choose to conduct chores on a Saturday when she is not working:

I never put the washing machine on overnight anymore…since the solar was put in I used to before then. Although I do washing on a weekend, obviously I have to do some through the week, I never do it overnight. I try not to do anything overnight anymore.

I tend to wash and dry on a Saturday, it's habit. I'm not working so that's when the washing gets done. (Sophie)

Sophie works from home with her husband and conducts most household chores; fitting them in between breaks. Sophie prefers to get these chores done at the beginning of the day:

Because I work from home, I'd do some work and I work on the computer so I need some break anyway. But I'd just get it done (clothes washing), get it in and then go to work. But once you're at work, you kind of forget, don't you? So I just do everything at the beginning of the day. (Sophie)

There was a time when the chores were all done together but now most of the chores are done separately. This change in practice is to fit in and respond to solar PV generation:

Not now … I used to. But now I try and do it [household chores: laundry, washing and dishwashing] separately. The only thing that gets done together is the clothes washing and the drying. And I could change that habit to doing the washing on a sunny day but haven't. (Sophie)

Sophie has a secondary fridge-freezer in the kitchen which she uses to store pre prepared food:

The fridge, yes, that's just a freezer. This is a big freezer, chest freezer for immense amount of food. That means I can do a massive pan of soup and freeze it all. (Sophie)

The demands of work patterns means it is rare all the family members are at home together during the evening so family meals together have become a thing of the past. This trend has emerged only during the last year or so:

I don't know how I could change the way I cook. … No 'cause work. And to be fair with a 16 and 19 year old … they're out all the time at work. We hardly ever eat together; we cook when people want food.

We don't have family meals anymore. That's been changed for about a year, it's rare we're all in together. (Sophie)

Table 5.4.6b Consumption metrics - Case study 6: Sophie

Case Study 6: Consumption Metrics					
	Average 24 hr. consumption (kWh)	Average Day Time (AD) (kWh)	Average Night Time (AN) (kWh)	Average Peak Time (AE) (kWh)	24% (4pm-8pm) / Evening Consumption Factor
Sample	11.91	4.44	4.27	3.19	25 / 1.8:1
DL13	**22.76**	**8.67**	**7.63**	**6.47**	**28 / 2:1**
Standard deviation (DL13)	*5.52*	*3.48*	*1.71*	*2.36*	-
Difference (Sample Vs DL13)	10.85	4.23	3.36	3.28	3 / 0.3:1

The average 24hr electricity consumption 22.76kWh is significantly higher than the sample average of 11.91kWh. This could be because there are three adults and a teenager living in the household.

The household is particularly busy with a number of electrical appliances in use within the property daily.

Examining the consumption metrics the average day time consumption (AD) 8.67kWh is almost double the sample average 4.44kWh. Sophie and her husband are present within the home during the day with a number of electrical appliances and devices switched on.

With 28% electricity consumption 6.47kWh occurring during the evening period (4pm-8pm) and an evening consumption factor (ECF) 2:1, electricity consumption is at its highest level during this period; higher than the sample average 25% 3.19kWh. As the property is being heated by gas not electricity, this would imply some occupants are typically present during these periods carrying out practices such as cooking and washing.

The average night time consumption 7.63kWh is significantly higher than the sample average 4.27kWh. Sophie's daughter and son are present during the night and into the early hours of the morning using appliances and/or devices to fit in around shift patterns.

Case study 6 (Sophie) Summary

In this household both parents are using the house as a place of work. Office equipment is constantly running adding to the significant daily electricity base load present in the electricity metrics.

The footfall in and out of this household over a 24hr period is determined by the demands of work or socialising. Occupants rarely eat together; although meal times are intermittent Sophie ensures the freezer is fully stocked and when occupants need to eat they frequently cook ready meals in the microwave. Shower times are intermittent; again to fit in with the needs of shift patterns.

Sophie is aware the household is consuming high amounts of electricity daily but isn't too concerned about it; much of the consumption is attributed to the fact the home is used as a place of work.

Although Sophie's husband was influential in persuading her to install solar PV panels, feedback suggests the installation had the greatest influence over practices conducted by Sophie between her daily working duties. If the sun is shining, Sophie realises her solar PV panels are generating electricity and she will turn on her washing machine. It is interesting to find, although Sophie's husband led on organising the finance and the installation of solar PV equipment, since it was installed it is Sophie who takes advantage of the electricity it generates. Other members of the household have not adjusted their use of electricity in the same way.

Sophie's household is a good example of electricity consumption being dictated by the demands of work life and shift patterns. Sophie is central to the way chores are conducted within the home and adapts her practices to respond to solar electricity generation. Although Sophie has attempted to be flexible around practices such as clothes washing, Sophie does not feel she can be flexible around the use of their office equipment which contributes significant base load to their electricity consumption as illustrated in the consumption metrics. The office equipment is central to the economy of this household as it generates an income therefore there is little room for manoeuvre.

5.4.7 Case Study 7 [DL15 (Arthur) Interview]

Table 5.4.7a Case study 7 (Arthur): Profile

Case study 7	Profile
Interview ID	DL15
Name(s)	Arthur
Occupation	Retired
Number of people	3
Household Income	>30,000
Time in property	30
Age of property	1985
Thermal efficiency	Middle
Tenure	Owner Occupier
Test Cell	20 (Solar monitoring)

DL15 (Arthur), this household consists of a retired couple; Arthur and his wife. The interview was undertaken with Arthur. As part of the CLNR trial, Arthur received a meter to monitor the amount of electricity his solar PV system was generating and exporting back to the electricity grid.

The house is off the gas grid, set in a rural cul-de-sac. It is a large (1600 sq. ft.) detached property which Arthur designed and built in the 1960s:

We are 1600 square feet here so it's quite a large property.

All the properties on this cul-de-sac are all self built. (Arthur)

Arthur and his wife have five grandchildren aged one to eight all of which live locally. Four of the children are cared for by Arthur and his wife four days a week. Whilst the grandchildren are being looked after by their grandparents, they often play on games consoles and other computing equipment. The arrival of grandchildren means adjustments have been made to the house:

We've child proofed certain areas of the house.

We have three children and five grandchildren.

They vary from age 1 to age 8, four of them have full days here. They live within a few miles, there is regular contact.

They like to play on the Wii and they also play on the computer. (Arthur)

Recently, Arthur's daughter unexpectedly returned to the home with one of the grandchildren. This is understood to be a temporary situation and his spare bedroom has been opened up to accommodate them:

My daughter recently moved home with one of our grandchildren, it was a bit unexpected but we are dealing with it, we don't expect it to be a long term thing maybe about three months or so…

They are staying in one of the spare bedrooms; we've plenty of space. (Arthur)

Arthur's technical knowledge of electricity consumption and thermal performance of buildings is exceptional. Arthur is naturally inquisitive in all walks of life:

I do make enquiries and ask daft questions to people who think I'm an idiot. Everyone I meet I always have an objective of trying to get a little bit more information from them. (Arthur)

The level of knowledge derives from Arthur's career as a mechanical engineer and is embedded into the design of his home and applied to shape the way electricity is consumed and exported back to the electricity grid daily. Arthur is an innovator; when he designed his home approximately thirty years ago he insulated it to the standard he thought was required, not to the standard recommended by builders at the time:

Ok so this is a well insulated house. It's a double cavity wall and both walls are insulated. You'll be aware it's not hot in here [summer during time of interview]. *All outside walls are very thick, we have an artificial stone wall, a four inch in here met here by an exterior wall both of which are four inches thick.*

When I built the house thirty years ago I was ahead of the times. I insulated to the standard I thought was required, not what any build at the time thought was required. (Arthur)

Arthur is central to the way electricity is consumed within this household; he designed the electricity circuitry and installed equipment to reduce the cost of electricity consumption whilst also maintaining reliability and overall efficiency. Prior to the interview taking place, Arthur prepared a drawing of the electrical circuit. The image illustrated how Arthur had manipulated his electrical circuit to ensure he and his wife never use more than two tanks of hot water. Arthur has designed his electrical circuit to ensure hot water is never heated by on-peak electricity. The circuit has been designed by Arthur to provide maximum flexibility:

There are two tanks, one feeding into the other. The idea is we never use more than two tanks of water so we never use on peak electricity to heat the water. It is always heated during the night.

We can switch between economy seven and the twenty four hour circuit.

Economy seven turns off 7 o clock in the morning. Then we are down to very low usage during the day, fridge, freezer, TV. That's more or less the base-load until about midnight; the TV, fridge and freezer.

All the plumbing, all the plasterboard all the electrics I did myself. (Arthur)

Arthur and his wife enjoy spending time in the allotment in their garden which yields large amounts of fruit and vegetables. They have installed a secondary freezer to store allotment produce:

Being retired and having an allotment next door, we produce a lot of our own fruit and veg. I need a secondary freezer to store it all. (Arthur)

Arthur currently heats the property using electric storage heaters, but concedes these will have to be replaced shortly. Arthur is considering air source heat pumps to replace his ageing electric storage heating:

I'm actually looking at air source heat pumps on the grounds that my electric storage heaters are now thirty one years old. (Arthur)

Arthur and his wife use their washing machine if it is a sunny day; if it's cloudy they will consciously wash clothes during the night. Before the solar was installed washing was done through the night taking advantage of an economy seven tariff:

Yes but in a fun way not a concerted effort to make use of it. My washing machine, if it's a sunny day we'll use the washing machine during the day. Before the solar panels we'd wash during the night on economy seven. If it's a cloudy day we'd wash during the night. You'll appreciate new washing machines are cold fed. (Arthur)

Arthur and his wife always have a cold lunch during the day, however in the evening they prefer to eat out rather than cook meals at home. When cooking does take place, in the evening it is typically between four o'clock and six o'clock:

We've both retired so there's not a lot of cooking going on. We eat out quite a lot.

Cooking, it's invariably between 4 o' clock and 6 o' clock.

During the day I'll always have a cold lunch, maybe have a cup of tea.

We're very old fashioned in that respect. Three meals a day, table set TV turned off. The grandchildren don't. It's a social event is eating.

Arthur and his wife use timers to cook large meals through the night:

If we are cooking a big roast turkey we'd set the timer on the cooker to come on during the night, that's only if there was a large amount of cooking to be done. (Arthur)

Arthur believes the microwave offers a more economical way to heat food and liquids. The microwave is often used to warm up a cup of instant coffee; the kettle is preferred when making tea:

The microwave is used quite often. We have a belief between us that the microwave is a much more economical way of cooking. We also like it for simple things like if you want a cup of coffee you can put it in the microwave and turn it on for two minutes and then you have instant hot water. We go for instant coffee. If we're having tea we use the kettle. (Arthur)

Arthur's wife showers every day however Arthur's showering is less frequent.

My wife has a shower everyday but I don't. I'm Henry the VIII style (laughs) I do have a shower at least once a week. It's predominantly showers, very little baths. It hasn't changed. (Arthur)

An electric fire is located in the living room and Arthur perceives its purchase and usage is attributed to the fact he and his wife are ageing:

As you can see we also have an electric fire.... it's about ten years old. That was a concession to old age, when you begin to feel the cold. (Arthur)

Table 5.4.7b Consumption metrics - Case study 7: Arthur

Case Study 7: Consumption Metrics					
	Average 24 hr. consumption (kWh)	Average Day Time (AD) (kWh)	Average Night Time (AN) (kWh)	Average Peak Time (AE) (kWh)	24% (4pm-8pm) / Evening Consumption Factor
Sample	11.91	4.44	4.27	3.19	25 / 1.8:1
DL15	**13.45**	**5.24**	**5.33**	**2.89**	**21 / 1.4:1**
Standard deviation (DL15)	*2.47*	*1.94*	*1.47*	*0.82*	-
Difference (Sample Vs DL15)	1.54	0.80	1.06	-0.30	-4 / -0.4:1

The average 24hr electricity consumption 13.45kWh is higher than the sample average of 11.91kWh. There are two retired people living in the household and it is heated by electricity so this explains the higher level of consumption.

Examining the consumption metrics in further detail reveals in comparison to the sample average 4.44kWh, this household is consuming a higher level of electricity 5.24kWh during the daytime period. Arthur and his wife are present during the day using electrical appliances and/or devices.

With 21% of daily electricity consumption 2.89kWh occurring during the evening period (4pm-8pm) and an evening consumption factor ECF of 1.4:1; electricity consumption is marginally higher during this period but comparable to the sample average of 25% and sample ECF 1.8:1.

The average night time consumption (AN) of 5.33kWh is higher than the sample average 4.27kWh. As the property's electric storage heating is charged through the night and water heating also takes place intermittently this level of consumption is not surprising.

Case study 7 (Arthur) key observations:

Arthur's knowledge of the entire electrical system derives from his career as a mechanical engineer but his level of enthusiasm and inquisitive nature around electricity consumption is unique. At the time of interviewing the household is experiencing a period of fluidity; Arthur's daughter and grandchild have moved into the property and this living arrangement now means three generations are living under-one-roof. Zones once redundant and used for storage have been opened up to accommodate this temporary situation.

Arthur is central to the way electricity is consumed in this household with his wife taking a passive role. Arthur controls and monitors his electricity consumption daily and has gone out of his way to manipulate its circuitry to ensure cost is minimised whilst efficiency is maintained. The property is thirty years old but insulated to a standard beyond today's building regulations.

Arthur and his wife understand social trends now mean they are grandparents ten years later than they would have been if their children had produced children in their twenties instead of their thirties. Arthur and his wife accept this is simply how social trends have emerged but they find it difficult to keep up with their young grandchildren's energy. Adjustments comically referred to as 'child-proofing' have been made in the home to accommodate the grandchildren.

Case Study 8 [DL17 (Michael) Interview]

Table 5.4.8a Case study 8 (Michael): Profile

Case study 8	Profile
Interview ID	DL17
Name(s)	Michael
Occupation	Lorry Driver
Number of people	1
Household Income	15,000-29,999
Time in property	30 yrs.
Region	York's & Humber
Age of property	1960s
Thermal efficiency	Middle
Tenure	Owner Occupier
Test Cell	5 (ToU)

DL17 (Michael) lives in a three bedroom detached house. Michael's wife died approximately five years ago and he now lives alone. Michael signed up to the CLNR study to be part of test cell five studying to what extent he could be flexible in his electricity demand when offered a time-of-use tariff.

Michael works as a lorry driver and his work pattern often means he is away from the household most of the day, leaving early morning and returning in the evening. Early starts at five o'clock in the morning means Michael often goes to bed early. Michael's house is effectively closed down during these periods:

I'd go to bed probably around nine to half past [21:00 to 21:30] and I'm up at 5 o'clock [05:00], most mornings. No breakfast, straight out, quarter an hour and that's it. Wash, brush my teeth, dress and out. I'm on the road at six o'clock [06:00] (Michael)

From a young age, Michael has been interested in energy issues and is able to recite an essay he wrote on 'North Sea Oil.' As a Yorkshire miner, Michael's dad passed down knowledge and know-how around energy use to Michael:

I've always been aware of energy use, as a kid I remember writing an essay about North Sea Oil and thinking we should make this oil last.

Not just the money side, I try to recycle everything I can because the way I see it when I go other people will want to use scarce resources. (Michael)

Michael's father used to conserve energy. Michael is keen to follow suit and recently installed solar PV. Since the installation, Michael adjusted his electricity use daily to ensure the electricity generated is used. This adjustment is particularly evident around cooking, washing and showering practices:

I installed the solar in Feb last year (2012) 14 panels. I can get up to 3.12kW. A company called Green Sun based down south installed them.

I didn't get any advice on how to use them or take advantage of the solar being generated. I just learned this myself. (Michael)

Using the flashing light on his generation meter, Michael monitors the amount of electricity being generated by his solar PV. Michael adapts his behaviour to ensure electricity being generated by the solar PV is used onsite. Michael also considered purchasing an export meter to help him monitor levels of electricity generation being fed back to the electricity grid:

I use the generation meter as a guide to see how much I'm generating. It has a flashing light I count seconds in between to see how much it is generating.

I try and I'll even cook things when the sun shines or get a shower when the sun's shining if I can. Obviously, if I am at work I'll get a shower in the evenings now. I just try and make full use of the solar panels.

Generally speaking it's still cheaper to heat my house off the gas than the electric. But if I am generating it [electricity], if I had an export meter I would be able to tell. I would take readings in the morning and reading on the night and I would pick comparison you know. (Michael)

Michael monitors weather conditions for the following day; if it is going to be a sunny day Michael will set a timer to enable his washing machine to turn on during the day:

I'll check the weather the day before, if it's going to be a sunny day and I'm out at work I'll put it [washing machine] on a timer, a delay so it comes on half past eleven in the morning. I'm aware of risk but I've got circuit breakers in.

I think I'm not washing today because it's not sunny. But sometimes you've just got to do it (Michael).

Before solar PV was installed Michael typically washed his clothes during the evening period:

Before solar was installed I would wash on the evening; didn't matter what time, I was on the same flat tariff so didn't matter. (Michael)

Michael often cooks ready meals using a microwave; he considers this method efficient as it takes advantage of the electricity generated via his solar PV panels:

If it's a sunny day I'll use the microwave to cook my meal instead of cooking using the gas hob, not always but sometimes. I'm actually purchasing more ready meals from the supermarket, as a lorry driver this also fits in with my lifestyle.

If it's been sunny and I have the option of a microwave meal or something else I'll use the microwave (Michael)

On his day off work, Michael will shower during the day if the sun is shining; further evidence Michael is shaping his practices to meet solar electricity generation.

I will shower every day in evening when home from work, but during days off if it's sunny I might have a shower middle of the afternoon as opposed to this evening. (Michael)

Michael's house is south facing; an ideal orientation to gain heat from the sun. During the colder months, electric halogen heaters are used to heat the home; one in the living room and another in the kitchen. Michael prefers to use halogen heaters than heat his home using his gas fires or boiler, however, if it is particularly cold in the winter Michael will use his gas boiler:

One of the reasons I bought this house was because it was South facing.

Because south facing I don't tend to use the heating between April and September odd day for heating. Mind you I did have to turn it on during July.

I use halogen heaters; I put them on when the sun's shining in winter. I'll use them first before I put the gas fires on, especially if I know it's going to be a sunny day. I'll actually put them on, on a timer to come on when the sun's up.

I used the timers even before I was put on the tariff, so I knew it would suit me!

During the winter, I'll use my halogen heaters to heat the house instead of using the gas boiler. I put one in the living room and another in the kitchen.

If the house is still cold then I'll use the gas. (Michael)

Table 5.4.8b Consumption metrics - Case study 8: Michael

Case Study 8: Consumption Metrics					
	Average 24 hr. consumption (kWh)	Average Day Time (AD) (kWh)	Average Night Time (AN) (kWh)	Average Peak Time (AE) (kWh)	24% (4pm-8pm) / Evening Consumption Factor
Sample	11.91	4.44	4.27	3.19	25 / 1.8:1
DL17	**8.55**	**4.18**	**2.90**	**1.47**	**17 / 1.0:1**
Standard deviation (DL17)	*5.06*	*4.21*	*1.17*	*1.15*	-
Difference (Sample Vs DL17)	-3.36	-0.26	-1.37	-1.72	-8 /-0.8:1

Average 24hr electricity consumption 8.55kWh is below the sample average 11.91kWh.

Examining the consumption metrics further reveals in comparison to the sample average 4.44kWh, this household is consuming a marginally lower level of electricity 4.18kWh during the daytime period. Michael's occupation as a lorry driver means four days a week he is away from his household during the day. During these times Michael sets timers on his washing machine and (weather dependent) his halogen heaters to ensure any electricity generated by his solar PV is used. Setting timers to ensure electricity is consumed for clothes washing means Michael's evening consumption is reduced. 17% of electricity is consumed during the evening period in comparison to the sample average, 25%. Michael demonstrates flexibility in relation to clothes washing, cooking and heating.

Case Study 8 DL17 (Michael) Summary

Michael is a good example of a hard working person living alone. Although the extent of fluidity is limited in this household, in future Michael may find himself subject to fluidity, for example, if he were to suddenly become unemployed or if he were to meet a new partner and allow them to move in with him. In this situation Michael's regimes and routines would be disrupted; a revised electricity profile would replace the current status quo.

Michael has full control over his regimes and practices attributed to electricity consumption. Of all the households in the sample, Michael consumes the highest proportion of his 24hr electricity

consumption during the day with a daytime consumption factor of 3.8:1; in contrast, little (17%) electricity is consumed during the evening and night. The qualitative data captured helps to explain the trends found in Michael's consumption metrics. Michael uses timers to control various appliances whilst he is out at work during the day Michael has taken advantage of the ToU tariff offered as part of the wider CLNR trial as it suits his daily routines.

Michael is actively engaged with his electricity supply and consumption, steered by a genuine appetite influenced by his father to conserve not just electricity but energy generally. Such level of engagement shapes Michael's behaviour daily to manage, monitor and maintain his electricity and general energy consumption. This household demonstrates knowledge of the energy system and a genuine willingness to engage with it.

Chapter 6: Analysis

6.0 Introduction:

Qualitative and quantitative findings are analysed to identify emerging patterns of behaviour and trends influencing domestic electricity consumption. Particular focus is given to evidence of household fluidity, investigating the role it plays in shaping electricity consumption.

6.1 Case study analytical framework

The eight case studies presented in the previous chapter are analysed using an analysis framework. The framework is constructed using themes emerging from discussions of the qualitative research process and the literature reviews. An explanation of each theme contained within the framework is outlined in the methodology chapter. It is worth pointing out the themes in Fig 6.1 aren't independent and the relationships between them help to further our understanding of domestic electricity consumption.

Figure 6.1 Analytical Framework: Qualitative Analysis

Hubs and environments
Rhythms and thresholds
Health and well-being
Conflict and contestation
Economies
Accomplishing energy services & practices
Knowledge and know-how
Technical legacies and novelties

The qualitative analysis helps to understand the reasoning behind the patterns of 24hr electricity consumption presented in the data metrics. Analysis from the wider CLNR sample of 131 households is also used to validate the traits and characteristics of fluidity emerging from the sample of 8 household interviews. The chapter begins by analysing the case studies using the themes in the table above.

6.1.1 Hubs and environments

The analysis reveals strong links between hubs and environments and how they are adapted to meet the needs of household fluidity.

It is parents who make sacrifices to re-accommodate their adult children when they return to the paternal home. During this fluid period the parents' behaviour is altruistic in nature; they sacrifice their own interests for the needs of their children (Wilk 1991). Parents in the sample had to adjust and realign their household environment; we recall Mancini & Bliezner (1986) who states the impact refilling the nest has upon parents:

> 'what may pose a bigger adjustment problem for parents is the "refilling" of the empty nest, when adult children return to live with parents or when ageing parents move in with their middle-aged children.' (Mancini & Bliezner 1986:194).

Parents in the sample found themselves converting storage rooms back into bedrooms when adult children move home or dining rooms into playrooms to accommodate grandchildren. Evidence of adapting hubs and environments was particularly prevalent in the case of Arthur, Eve and Heather. Arthur had used one of the spare rooms for storage but opened it back up to accommodate his daughter and granddaughter. Arthur 'child-proofing' his home is a good example of parent sacrificing freedom of his own home and adapting to meet the needs of 'boomerang children' (Mitchell 2006:62) and grandchildren. Similarly, in the case of Heather when her two adult sons returned to their parental home she was required to reopen two bedrooms; one previously used as a storage and the other a guest room**.** Heather's returning sons in their 40s is a good example of 'intergenerational co-residence.' (Mitchell 2006:62)

Arthur, John and Mary demonstrate that having children greatly increases the risk of future exposure to fluidity in relation to hubs and environments. When grandchildren arrive, what was once a family dining area is often converted into a playroom followed by the installation of electrical appliances such as televisions, DVD players and gaming devices, all placing additional electrical load onto the household. Ageing of grandchildren naturally creates fluidity as they grow up developing independence, new interests and hobbies. As Eve's case study demonstrates, rooms are also converted when children move in the other direction; away from the parental home. When Eve's daughter moved out two years ago, her bedroom was converted into a playroom for Eve's childminding business.

Adapting hubs and environments to accommodate the return of children and/or the arrival of grandchildren illustrates how fluidity can spring previously unused areas of the home back into use. Increased electrical load in the revised hub or environment is a by-product of this transition.

It is not only the arrival or departure of household members which can influence the way hubs and environments are used. Eve's partners' unemployment meant he was present for long periods during the day preferring to stay out of the way watching television or playing video games upstairs in their main bedroom whilst Eve is downstairs looking after the children. The fluidity in circumstance meant two hubs were active during the day. The consumption metrics illustrate Eve's household had the second highest daytime electricity consumption in the sample. Her partner's fluid employment status keeping him at home was a source of additional electricity consumption.

6.1.2 Rhythms and thresholds

Fluidity can influence the timings and thresholds aligned to various domestic practices. Perhaps most evident in the case of Heather, in this household rhythms and thresholds in relation to showering, cooking and clothes washing are designed to fit around the needs of her two adult sons living in co-residence. Heather perceives it as her duty as a mother to provide her sons with a hot meal when returning from work in the evening, performing this routine five days a week. Heather's kitchen appliances are all electric (preferring it to gas) thus she consumes almost a third of her 24hr electricity consumption during the 4pm to 8pm period. In Heather's household such 'altruistic' (Wilk 1991) behaviour has become routinized. However, arguably, this situation is in itself subject to fluidity. Heather's sons could move out at any time and, as an elderly lady, her health could deteriorate requiring her sons to take a leading role in washing and cooking practices. If either of these circumstances were to occur it remains unknown as to whether the same rhythms and thresholds would be applied under the revised household structure.

Following similar daily habitual routines to Heather are John and Mary, although they experimented shifting meal times in the past this behaviour wasn't sustained. Such behaviour echoes the 'fallback effect' cited by (Wilhite and Ling 1995). During the week, meal times are structured around watching the six o'clock news. This routine was evidenced in the consumption metrics, with 36% of their total 24hr electricity consumption (kWh) occurring during the evening period and an evening consumption factor of 2.9:1; higher than any other in the sample.

In contrast to John and Mary, Nicola's household represents a busy family environment with two adults and three young children. In this case, rhythms and thresholds related to daily electricity

consumption are determined by routines of clothes washing, cooking and showering, carefully scheduled to fit in with the needs of schooling. The manner in which the boys are consuming electricity within the property is in itself subject to fluidity; patterns of electricity consumption will change as the boys develop their own interests away from entertainment consoles and gain independence, becoming less reliant on each other and their parents. The nature of this churn links with the natural 'change and continuity in practice' argued by Gram-Hanssen (2011:62)

Eve's childminding duties mean she follows a similar daily routine to Nicola, collecting children from school and feeding them during the 4pm to 6pm period ready for parents to collect them. Eve was subjected to two forms of fluidity in that the number of children 'on her books' had fallen and her partner was unemployed at the time of interview. Both circumstances carry implications for patterns of electricity consumption, although it is difficult to identify the weight of each factor independently. In the cases of Heather, John and Mary, and Nicola the routinized nature of rhythms and thresholds particularly in relation to meal times are synonymous with practice-based accounts (Warde 2005, Shove 2010) of energy use.

Analysis of Michael's interview and 24hr consumption metrics illustrates a sense of control and structure around electricity consumption. Michael represents a single person household. Electricity consumption is determined by shift patterns and electricity generation by solar PV panels. Michael uses timers to ensure most of the electricity generated by solar PV is used during the day to provide background heat, wash clothes and shower during days off from work. The consumption metrics illustrate that Michael uses very little electricity during the evening 4pm-8pm period. As Michael currently lives alone he enjoys full control over his electricity consumption. Although Michael has experienced fluidity in the past due to the death of his partner it is somewhat difficult to see where fluidity may play a role in changing the current state of play. It would require something dramatic such as Michael to meet a partner and allow them to move in with him to shift his current patterns, rhythms and thresholds in relation to electricity consumption.

In contrast to Michael, Sophie's household consumes more electricity daily than any other in the sample. A significant proportion of electricity consumption is used to run her office equipment within the home which is left running constantly. Occupants are rarely at home together, the timings of energy related practices, cooking and showering is intermittent. One area Sophie does like to control is clothes washing which she adapts to fit in with her solar PV generation. Arthur also takes care to ensure washing is conducted when the sun is shining taking advantage of solar PV generation. Arthur's property is connected to an economy seven tariff; thus his property is supplied

with cheaper rate electricity during the night. Arthur and his wife will set programmers to cook large portions of meat during the night. Michael Sophie's and Arthurs behaviour demonstrates interconnectedness between everyday practices (clothes washing, showering, and cooking) and domestic technologies (solar PV, timers, programmers), Michael and Sophie's practices have, 'co-developed with technological systems over time' (Shove 2003, Gram-Hanssen 2011:76).

6.1.3 Health and Well-being

The analysis finds changes in peoples circumstance can throw households into a period of fluidity and transitional flux.

Tina is a good example to demonstrate how changes in health and well-being can impose periods of fluidity upon households. Five years ago, Tina's mother passed away and she decided to move to a smaller dwelling. Initially Tina had two years of good health, adjusting to life without her mother. However, approximately three years ago, Tina's health started to decline and this currently implicates her daily patterns of electricity consumption spending prolonged periods in bed and abstaining from practices such as clothes washing and showering. Tina's consumption metrics illustrate her restricted lifestyle with the lowest daily consumption (5.62 kWh) of all the case studies in the sample.

Based on the qualitative data presented and observations made on the day of her interview it is reasonable to assume Tina may require in-home assistance in the future. In-home assistance will involve someone coming into Tina's home to provide support with domestic chores such as showering, clothes washing and cooking. The system of provision will inevitably shift the current timings and thresholds by which these chores are carried out, changing current daily patterns of electricity consumption.

John and Mary share a similar plight. Mary's health is deteriorating and John is slowly required to take a greater role in the domestic chores previously conducted by his wife. It is reasonable to assume a new person conducting domestic chores on behalf of Tina and Mary will stamp their own routines, timings and thresholds by which chores are carried out.

6.1.4 Conflict and contestation

Households in fluidity are more likely to experience conflict and contestation in relation to electricity use.

Where households experience higher footfall and flows of people daily, there is greater opportunity for conflict and contestation in relation to electricity use to occur, particularly evident amongst parents and their children and/or grandchildren. Evidence of conflict and contestation was particularly prevalent in the case of Nicola and her three sons, Heather with her two adult sons, Eve her partner and her son and Arthur with his returning daughter and grandchild.

In Nicola's household, gone are the days where children should be 'seen and not heard' synonymous with 1950s family life. Nicola perceives her three sons as central to patterns of 24hr electricity consumption; each owning an xbox entertainment system. Nicola takes measures to reduce conflict when the consoles are in use allowing her two boys (twins) to operate their xbox in their individual bedrooms, whilst her other son uses his downstairs in the main living room. The zonal regime to keep the peace means Nicola's boys are consuming electricity within three areas of the home after school between 4pm and 6pm whilst Nicola is making the evening meal in the kitchen. Nicola and her husband appreciate they incur additional cost imposing this regime but are 'willing to make sacrifices' incurring additional costs to reduce conflict and contestation amongst the group (Wilk 1991).

Sophie and her husband perceive themselves as the main consumers of electricity acknowledging multiple electrical appliances are left running throughout the day as they run their business. Sophie does not perceive this consumption as wasteful but more of an economic necessity as it generates income for the household. Sophie interprets her children as wasteful in relation to electricity use particularly as their consumption does not yield any economic return to the household.

Although the analysis suggests conflict and contestation is exacerbated when (grand) children or adult children are in living co-residence it also continues when they leave but is redirected between husband and wife; evidenced in the case of John and Mary. John made multiple references to Mary's wasteful tendencies but did so in a light-hearted manner as to convey her energy behaviour was a form of daily entertainment for him. John joked about the number of lamps in the home and laughed at Mary's dislike of main lights.

John, Arthur, Sophie, Heather and Eve deflect any blame for high electricity bills or wasteful tendencies away from themselves onto other people within the household. Of course, a note of

caution is required; only one side of the story is told, the author acknowledges this as a limitation of the research.

6.1.5. Economies

'Consumers will adapt usage in response to price signals.' (Chatterton 2011:6). At the time of interviewing energy prices were increasing and frequently featured in the news headlines. All respondents in the sample referred to steps they had taken to reduce electricity consumption. The analysis finds consumers not only adapting their usage but also taking steps to incubate themselves from future price increases. Eve's caseload working as a childminder had reduced due to the recession and her partner became unemployed thus experiencing fluidity. To help manage household energy bills at a time when her household income had reduced, Eve changed her billing schedule from monthly direct debit to payment upon receipt of the bill. Eve felt paying in this way provided a sense of control but envisaged returning back to monthly direct debit once her partner returned to work and/or her caseload increased. Eve's circumstance is a good example of a household managing an energy supply contract in response to short term fluidity and is undoubtedly replicated across many UK households particularly amongst those in fuel poverty. Energy suppliers should take note as Eve's case demonstrates how fluidity can impose itself upon billing arrangements.

In the case of Arthur, Michael and Sophie, installing solar PV helped mitigate rising electricity prices, each noting as electricity prices increased, the higher value their PV electricity generation would become. These households were in a fortunate position to have access to finance to install solar PV; providing a long term sense of control. In contrast, less affluent households in the sample made difficult decisions to economise.

6.1.6 Accomplishing energy services

Sophie, Michael and Arthur all embraced new technology in the form of solar PV, adapting some of their practices to take advantage of the electricity it generates. Each checks the weather forecasts daily setting washing machine timers to come on during a sunny day. Doing so ensures any electricity generated from the PV is being used on site, particularly useful to accomplish clothes washing. According to Spaargaren (2003), Sophie, Michael and Arthur are simply, 'making use of the possibilities being offered to them' (Spaargaren 2003:688). In contrast, laggard Heather had only recently installed a gas condensing boiler resisting the installation of gas for some time preferring traditional forms of heating. In her kitchen, Heather's appliances were dated, demonstrated by the presence of a 1980s spin dryer used to dry clothes and an early 1980s cooker. Although dated and

inefficient, Heather was familiar and felt secure using these appliances to accomplish her daily practices. Heather's sons in co-residence didn't appear to have much influence in encouraging her to modernise her appliances although their perspectives were not captured as part of the interview.

Tina prepares a cooked meal daily but dislikes the smell of food being prepared. As a result, she frequently purchases sealed ready meals. Typically, in the UK ready meals are prepared using a microwave, but Tina chose to prepare them using her conventional electric oven. Incurring additional cost does not concern Tina as she prefers the taste of the end product cooked in this way. In contrast, Michael frequently uses his microwave to prepare cooked meals valuing the convenience this method offers whilst also viewing the microwave as more economical to operate than his gas oven. Convenience and economics play a part in Michael's method of accomplishing a cooked meal. Living alone means Tina and Michael enjoy full control over their practices be it preparing a main meal, clothes washing, showering or entertainment.

6.1.7 Knowledge and know-how

Reckwitz (2002) draws particular importance on the role of knowledge and know-how in shaping everyday practices. 'The difference between energy users illustrates that they are not a homogenous set of individuals' (Chatterton 2011:6), the case studies conclude with this view. Arthur, Michael and Sophie particularly stand out demonstrating higher levels of knowledge in relation to electricity use than the others interviewed. A common denominator between them was that they each had personally invested in the installation of solar PV.

Of all the cases presented, Arthur demonstrates a distinctively high level of knowledge in relation to electricity consumption. It was Arthur's career as a mechanical engineer which instilled such high levels of knowledge and expertise. In the case of Michael, the knowledge and know-how passed down by his father helped to shape his current patterns of electricity use. Michael grew up listening and learning from his father about energy issues and could recall an essay he wrote on North Sea oil as a young teenager at college. The knowledge gained from his father and curricular interest provided the foundations for Michael's interest in issues related to energy today. Michael's investment in solar PV is confirmation of a genuine interest in managing his domestic electricity consumption, earning an income whilst also reducing his carbon footprint driven by 'ethical concerns around energy conservation' (Herberlein & Warriner 1983, Katzev & Johnson 1983).

Knowledge and know-how links to other themes in the analysis framework in that it feeds power and contestation, the analysis suggests those with higher levels of knowledge in relation to electricity consumption will take an authoritative stance. For example, where a member of the household possesses strong knowledge and know-how (e.g. Arthur, Sophie or John) in relation to domestic electricity use they often try and fail to encourage others to follow the same patterns and traits as them. Authority is being realised through knowledge and knowhow (Wilk 1991).

6.1.8 Technical legacies and novelties

Arthur designed and built his home, considerable thought went into the design to ensure the fabric and the electric circuitry delivering heat and hot water was as efficient as possible. Arthur is proud of the fact that his home is insulated to a level far beyond building standards set at the time it was built. Arthur's pride resonates with Mirosa et al. (2011) "'achievement" is powerful in driving new behaviour.' (Mirosa et al. 2011:1) Arthur plans to modernise his heating and hot water system and he will apply his knowledge to inform this upgrade. Arthur's behaviour also omits a sense of 'intrinsic satisfaction' associated with saving or avoiding wasting energy as cited by (De Young 1996, Seligman et al. 1979).

In contrast to Arthur is Heather who had lived in her property since her marriage approximately 50 years ago. Heather could recall using coal to heat her home resisting the installation of gas central heating until just eight years ago when her old coal back boiler was replaced with a modern gas condensing boiler. Heather's ageing appliances such as her cooker, washing machine and 1980s spin dryer illustrates a resistance to modernising appliances preferring instead to use technologies she is familiar with.

6.2 Evidence of fluidity in the sample:

It would be naive to presume the extent of fluidity is uniform across all case studies, the analysis in this section reveals the prominence of fluidity is evidently stronger in some cases than others. The extent of fluidity in Michael's household is low, although he had experienced fluidity in the past following the death of his partner. The analysis illustrates he appears to be settled in his electricity consumption, well informed and confident to manage. Michael's case is useful as a comparator to the others.

Tina's past clearly illustrates she has passed through a period of fluidity to which she is still responding to. Tina's current electricity consumption and behaviour particularly attributed to cooking and washing is evidently shaped by her mother who conducted these practices for her. Since the death of her mother five years ago, Tina continues to adjust to living and coping on her own. Tina does not own a washing machine, nor does she cook freshly prepared meals, partially due to the fact her mother used to perform these tasks for her.

Across the remaining five case studies the evidence of fluidity is evidently strong and at times volatile. In the case of Eve, her partner being unemployed and her son moving away to university are examples of volatile fluidity. Arthur is in a similar position with the return of his daughter and arrival of his grandchild. Having analysed each household against the themes outlined in the thematic framework we can see where fluidity carries most prominence. Table 6.2 ranks the case studies illustrating where fluidity is most (1) and least (8) prominent in relation to each theme in the thematic framework. Using the table we can see how fluidity influences electricity consumption in each household.

Table 6.2: Thematic framework and prominence of fluidity across the sample

Theme **Evidence of fluidity shaping:**	**Most Prominent(1)_____(8)Least Prominent**
Hubs and environments	Arthur, Heather, Nicola, Eve, Sophie, Tina, John & Mary Michael,
Rhythms and thresholds	Heather, Nicola, Eve, Michael, Tina, John & Mary, Sophie, Arthur
Health and well-being	Tina, John & Mary, Heather, Arthur, Eve, Sophie, Michael, Nicola
Conflict and contestation	John & Mary, Nicola, Arthur, Sophie, Eve, Heather, Tina, Michael,
Economies	Eve, Tina, Michael, Heather, John & Mary, Nicola, Arthur, Sophie
Accomplishing energy services & practices	Heather, Michael, Tina, Arthur, Sophie, Eve, Nicola, John & Mary
Knowledge and know-how	Arthur, Michael, Sophie, Nicola, Eve, John & Mary, Heather, Tina,
Technical legacies and novelties	Heather, Michael, Arthur, John & Mary, Sophie, Tina, Eve, Nicola

6.3 Case studies compared to wider CLNR sample

For the purposes of verifying whether trends emerging from the eight case studies presented are representative of the wider CLNR sample (131 interviews), a tool in NVivo software (see

methodology chapter 4 for an explanation of NVivo) has been used to develop what is known as a 'Tree Map.'

Tree maps are used in social science research to assess the frequency of material coded to specific themes in an analysis framework, drawing a tree map for the whole sample and the sample of eight cases provides visual verification as to whether the case studies presented are representative of the wider sample. All themes in the thematic framework are represented by a box, the larger the volume of a box, the more frequently it has been used during the thematic coding process.

Chart 6.3a illustrates the tree map for the eight case studies. When compared to chart 6.3b illustrating the whole sample there are similarities in the volume of boxes attributed to the themes identified in the thematic framework illustrated earlier.

Figure 6.3a: NVivo Tree Map: Sample of 8 Case Studies (thematic nodes coded)

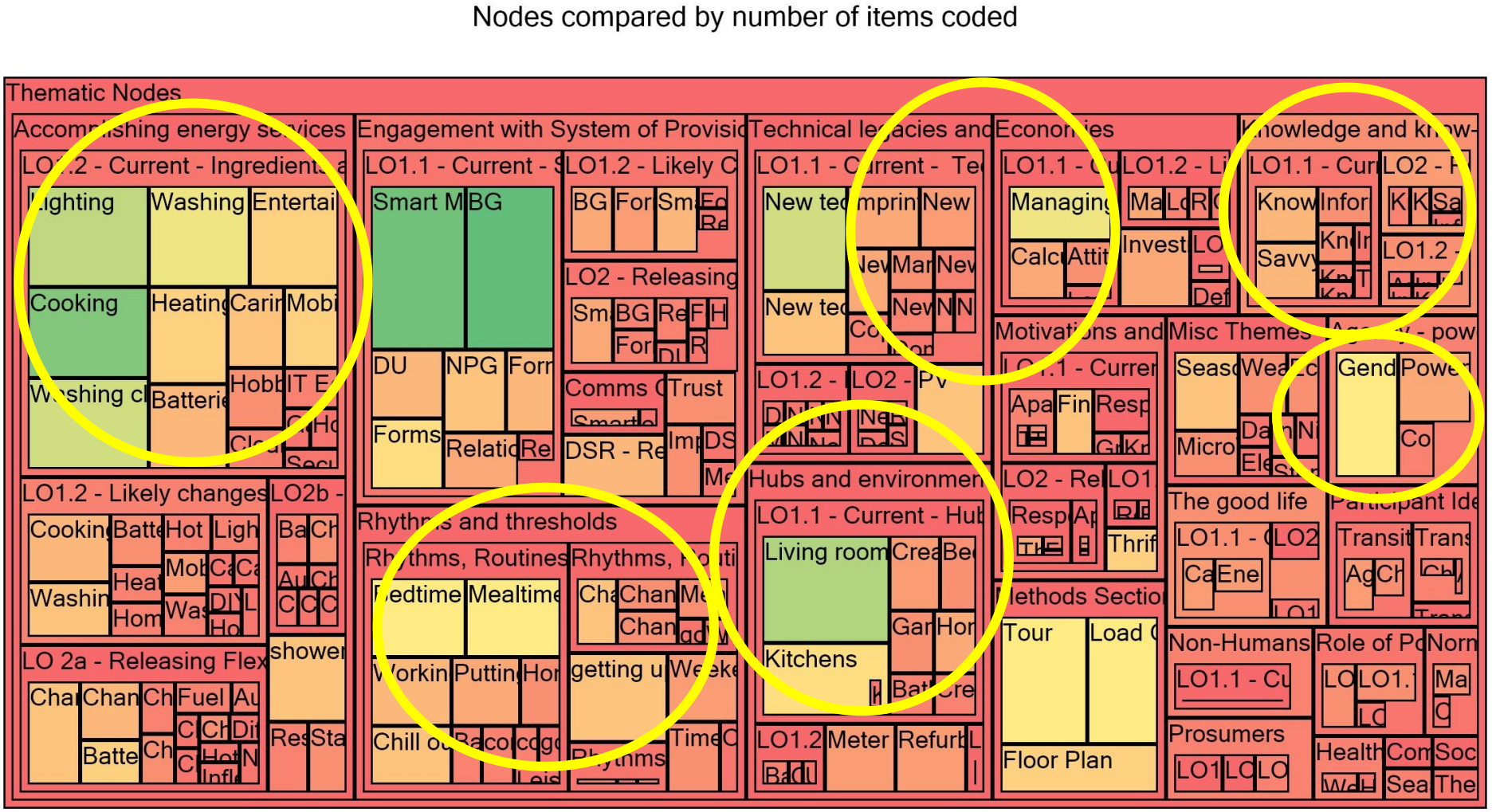
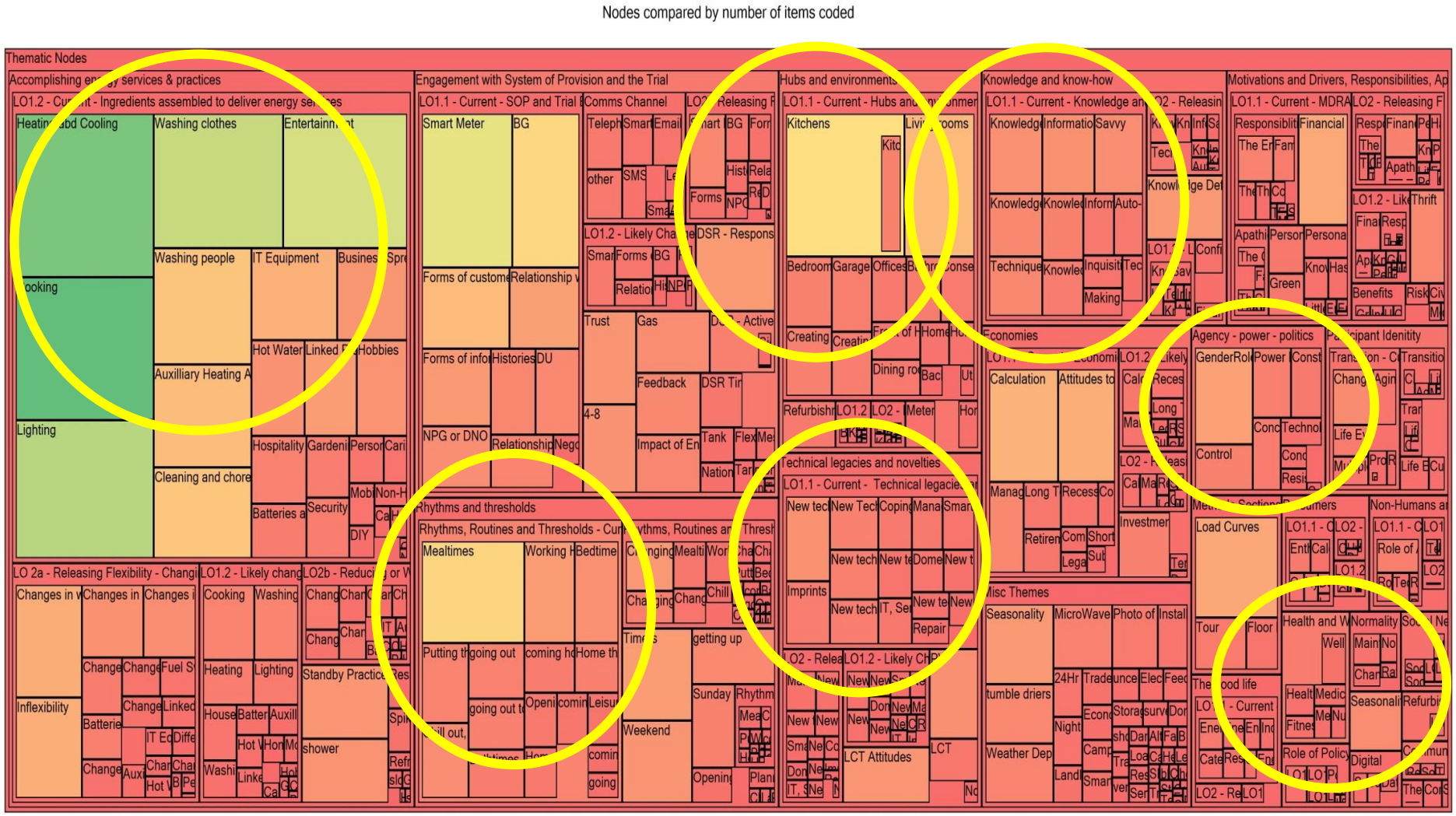


Figure 6.3b NVivo Tree Map: Whole sample (Thematic nodes coded)



6.4 Evidence of fluidity in the wider CLNR sample

The tree maps illustrate that the themes present in the eight case studies were also dominant across the wider CLNR sample. Further analysis is undertaken to explore the extent and nature of fluidity present.

Arthur, Eve and Heather's fluid circumstances are also found to exist within the wider sample with (grand)parent(s) responding to the needs of their (grand)/adult children sometimes at short notice, providing further evidence of volatile fluidity:

We have friends over for a weekend sometimes. And we have a son who lives down in [city] and when he comes up, that's him with his wife and two little children as well. They all come for the Sunday lunch if they're up here, everybody comes

Couple of months ago, our daughter who lives in [town name] decided to have a new kitchen fitted. And she said if we could look after the kids; two girls, sixteen and fourteen. And also do the washing for them. This was supposed to take a week but they stayed for a month! (MJRTL09)

Could I cook tea earlier or later than you do at the minute? No. I wouldn't do it. I couldn't do it. Na, Na. Me' grandson comes for his dinner, says I'll be here 5:45 so I couldn't. I'm set in my ways now, I never used to be but since I had all this. (GPML04)

Although not evidenced in the sample of eight case studies another example of fluidity emerging from the wider sample is that of the 'Sandwich Generation' (Mitchell 2006:186). In this instance, parents find themselves not only caring for their adult children but caring for their parents too. In this example, fluidity is dictating timings and thresholds related to cooking to meet the needs of the occupants:

We're stuck with catering for my mother, so we do give her a meal a day and that' usually in the evening. At this time of year it doesn't matter but in winter we are cooking at night. … my daughter (its hit or miss) she works a shift pattern and whenever (DL19)

6.4.1 Wider sample: Fluidity, conflict and contestation

The wider sample also reveals evidence of conflict and contestation in relation to electricity use. Not only evidenced where there is a presence of boomerang children but amongst households where adult children remain rooted to the parental home; living in co-residence:

On the top of energy usage is my daughter. As soon as she goes upstairs, she puts television on. As she's getting changed, television is on. When she was off Tuesday Wednesday and I think she's got through the whole box series of Friends, one, two, three (DL12)

Yesterday my daughter put soup in the microwave, I said what you putting soup in the microwave for!? It takes just as long on the gas and it costs less. (GP23)

Now at the moment I know it is on but I turn it off before I go to bed. He [son] wouldn't, he'd just put the DVD and the telly and not think about it, just leave the box on. (GP21)

Following a similar trend to our eight case studies, the wider sample provides evidence of householders taking steps to reduce conflict and contestation. Measures are taken to impose a structured routine around household chores; such measures keep fluid households aligned between busy work patterns. In this example a cleaning rota is used to encourage co-operation and structure:

It normally would be a weekend. ... if it's one of the [adult] kids then it would be through the week, during the day. Chores organised around various working patterns. There is a cleaning rota hanging in the kitchen. Arranged on a person/task basis. (EPJ19)

6.4.2 Wider sample: Fluidity, rhythms and thresholds

As with our sample, the wider data confirms practices such as cooking, washing clothes and showering are less structured in fluid households, particularly those containing adult children. In this instance, parent and child work patterns dictate the timing and extent of footfall within the home this, in turn, dictates timings and thresholds related to mealtimes, clothes washing and showering:

We just eat when we're hungry … (Daughter) will eat about half five, sixish, and I'll have mine any time after 3 o'clock. … I probably have a sandwich before I go to bed. (DL08)

It just depends who is in [about the washer]. Because me stepdaughter works at Marks & Spencer's so she's got midweek days off, she starts at five o'clock [05:00] and finishes at three [15:00] so that kind of random pattern. (EPJ19)

No [no shower in the morning], shower in the mid-day coz me daughter works shifts as well, so mid-day when she goes out coz she works in the restaurant. (GP29)

Microwave and Toaster there. Microwave, we don't really use it much, I never cook in it, I would never dream. I mean don't get me wrong, I always keep a couple of ready meals in the freezer, sometimes our son will come home, I'm hungry mum you got anything? (MJRTL14)

6.4.3 Wider sample: Fluidity, hubs and environments

Evidence of temporal hubs and environments found in the case studies are also represented in the wider sample. The feedback below illustrates adult children can live in co-residence with their parents but they may rarely see each other. Elderly grandparents may also temporarily give up their hub to accommodate their grandchildren:

The daughter (thirties) is upstairs. Me and my wife down here. My wife works four days a week so ... daughter works five. But when she's at home I never see her. She comes down, have her breakfast, go up, have a shower, get changed and that's it. (DL12)

When my other grandkids come they'll play on that stuff (consoles) At the moment we're living in the back room (because grandchildren are living there). The xbox, wii, … when they get their own place that'll all go. The little one is only allowed on it for now. (MJRTL04)

Once children move out, parents undergo a period of transition and realignment:

When she [daughter] was at home she had the heating on almost all day, sat in front of the computer. Now the heating is off. I may put it on for couple of hours at night when it gets cold. At winter it would have gone on for me about six o'clock (GPML01)

Since she's [daughter] been gone it is taking a lot longer to fill up the wash machine. (DL08)

Households containing retired individuals without the presence of adult children are sympathetic to those who do have them:

We now live solo but a number of people are retired like us but they still have got one or more children early in their thirties. (DL08)

7.0 Conclusion

The main aim of this thesis was to understand the influence of household fluidity upon domestic electricity consumption. I wanted to explore the characteristics of households in fluidity and whether such fluidity carried any implications for domestic electricity consumption. The research and data presented suggests household fluidity relates to sociological and anthropological based approaches to domestic electricity consumption. The analysis finds three common characteristics of fluidity related to a) occupancy levels, b) contestation and c) leadership. Each characteristic is now discussed.

7.1a Occupancy levels and fluidity

Analysis suggests a relationship between incidence of fluidity and occupancy levels. High occupancy increases the risk of fluidity and reduces the potential for households to be flexible in their electricity consumption. Households with multiple occupants and therefore greater daily footfall (Eve, Heather), or tied to daily structures of schooling, shift patterns or routines (Nicola, Sophie, John and Mary), are restricted in their ability to shift electricity consumption to other periods of the day, particularly during the evening (4pm to 8pm) period. In these fluid households, there is less structure and control around electricity consumption.

In contrast, analysis illustrates that low occupancy reduces exposure to fluidity but increases potential for flexibility in relation to electricity consumption. Tina and Michael both demonstrate willingness to be flexible around electricity use albeit for different reasons. Michael uses programmers to shift evening consumption to other periods of the day, taking advantage of his time of use tariff and solar PV generation. Michael's 'shifting' behaviour is represented in the consumption metrics, with the highest daily (8am to 4pm) consumption factor of the sample (3.8:1). Living alone, Michael is not constrained by the needs of other occupants and is able to control and manage his daily electricity consumption.

Tina's decision not to have a washing machine and cook microwave meals in her oven daily does not cause an inconvenience to her living alone, however if other occupants lived with her these behavioural traits may well be different.

7.1b Fluidity, a source of contestation

The case studies demonstrate multiple examples of conflict and contestation in relation to electricity use, exacerbated where multiple occupants are in residence. The case studies (Heather, Sophie,

Arthur, Eve) illustrate contestation between parents and children/adult children. Where children move away from the home, contestation continues but becomes focused between parents, particularly evident in the case of John and Mary.

7.1c Fluidity demands leadership

In fluid households there is often a leader taking responsibility for the running of the home, instilling rules or quietly trying to keep all occupants aligned. Leaders conduct practices such as replenishing food to ensure everyone is fed, clothes washing and other domestic functions. In the case studies presented Heather, Sophie, Nicola and Eve all illustrated traits of leadership, complementing the multi-functioning role of women in the household observed by (Mitchell 2006:183).

In the case of married or co-habiting households it is often the male who takes on responsibility for management and maintenance of energy supply contracts or adapting the technical infrastructure of the household; a trend demonstrated in the case of [John] and Mary, [Arthur] and his wife, Sophie and her [husband]. In each of these cases it was the female who negotiates use of the end product; using electricity generated by solar PV to perform domestic chores of cooking and clothes washing, consciously altering timings and thresholds to take advantage of electricity generation. The women in the sample put themselves on the front line actively trying to keep their households functioning during period of fluidity. When it comes to making changes to the technical infrastructure within the household it is the males who take a leading role in the decision making. This dimension somewhat challenges the purity of democracy, equality and egalitarian nature of households today as perceived by (Willmott and Young 1975 and Giddens 1991).

7.2. What impact does household fluidity have upon domestic electricity consumption?

The analysis finds household fluidity can give rise to changes in hubs and environments, opening up, closing down or redesigning them to meet the needs of realignment within the household. Fluidity can shift the status quo in relation to rhythms and thresholds as to when electricity related practices are carried out. Higher occupancy within the household increases the risk of conflict and contestation around electricity use.

In contemporary society, households may find themselves hit by unemployment or other circumstance attacking the economic status of the household. A process of realignment is required to adjust to revised economic constraints, contracts between electricity consumers and suppliers may be adjusted, rhythms and thresholds may be implemented by new household members.

7.3 Does household fluidity restrict or enable a household to be flexible in its electricity consumption?

Household fluidity restricts flexibility in relation to domestic electricity use; the reasons for this are multifaceted. The existence of adult children or grandchildren opens up hubs and environments previously, partially or fully closed down within the home. As footfall increases, the level of difficulty in keeping everyone aligned to conform to daily rhythms and thresholds around showering, clothes washing, cooking and entertainment is increased. Although adult children co-exist under the same roof, they may see each other infrequently, conducting their practices in different areas and/or at different times.

Those interviewed as part of this research illustrated it often requires intervention from a leader who will try to coordinate daily practices, replenishing stocks to keep the household functioning. Conflict and contestation around electricity consumption is never far away. It is most common between parent(s) and child(ren). Parents perceive their children as the main consumers of electricity; they also point the blame for wasting electricity in this direction. Periods of fluidity occur when adult children leave the parental home. Hubs and environments may be closed down or adapted to meet the needs of the revised household composition, however, there was evidence of diversity and nuances implying these findings aren't uniform, there were exceptions where zones continue to be used for different reasons. For example, rooms may be converted into zones for hobbies, an art or music room for example, there may be two rooms with a television to cater for different viewing habits or tastes.

It is often the case that parents perceive they gain greater control over their energy consumption when footfall within the home is reduced. Parents in the sample spoke positively around the impact this had on the level of electricity consumption within the home, for example, the washing basket taking longer to fill up or a reduction in energy bills.

The literature focused on families, kinship and households illustrated that post-industrial Britain gave rise to diversity and fluidity in household structures. Today the energy sector is busy developing a digitalised information rich electricity grid to cope with increased electricity demand and fluid household formations. In pre-industrial, industrial times the electricity grid emerged in its simplest form, driven by a basic need to provide power to the masses for basic domestic needs, lighting and heating. Back then, it was a non-digitalised mechanical system with cogs and dials.

Although this system was primitive and relatively simplistic, it gave birth to a whole new era of commercialism. Since then, we have experienced two or three generations actively encouraging people to consume electricity as a result of marketing, generating waves of electrical consumerism. What we are experiencing now is big screech of breaks!

Educational messages embedded in energy policy are requesting households to reduce their domestic electricity consumption. Arguably, domestic electricity consumers are receiving mixed messages with regards to electricity consumption; particularly in the case of cities. We are often recommended to use electrically powered transport, via electric cars, trams or busses and heat our homes using electricity. Yet, when it comes to electricity consumed by appliances we are asked to 'reduce' or 'shift' our consumption. At a policy level, current initiatives and incentives are not well geared to achieve the radical change required to deliver 80% reductions in UK CO2 emissions, nor the scale of demand response required from householders. Reports from the government's advisors on climate change claim information, advice and persuasion materials have been ineffective in keeping the UK on track to meet its carbon reduction. This thesis contributes to Strengers (2011) argument for social technical change 'beyond the current confused behaviour change ABC approaches and campaigns.' (2011:49).

Multi-disciplinary policy development is urgently required and should involve technological policy makers, distribution network operators and planners, energy supply companies and the regulator overseeing the market. These agents should consider emerging societal trends which are building new household dimensions behind closed doors. Over one in three of all marriages are now remarriages[9]. Stepfamilies are the fastest growing family forms in Britain accounting for one in ten of all families[10]. The number of single-parent families is growing, projected to rise by 31 per cent from 2013 to 2033 to just over 412,000. The fastest growing household type is households containing two or more families, increasing by 39% from 206,000 households in 2003 to 286,000 households in 2013[11].

The literature (Simpson 1994, Mitchell 2006, Roseneil 2013) on changing household forms and emerging social trends reaffirm the scale of household fluidity is increasing and becoming part of life course; energy suppliers and network planners should take note of this.

The empirical evidence found in this thesis suggests household fluidity does play a role in shaping who, how and when electricity is consumed. Current tariff structure offered by domestic energy

[9] Office for National Statistics (2011). Report. Household and families. Social Trends 41
[10] Ipsos MORI (2009). Report. The impact of changing family structures and what the public think.

[11] Office for National Statistics Bulletin: Families and Households 2013

supply companies offer limited support to some of the fluid households presented. Emerging tariffs such as ToU designed to shift demand away from the 4pm to 8pm peak period may appear to be a good deal to take in the short term, but its applicability maybe short lived due to a shift in household composition or circumstance. Dynamic tariffs aside, energy supply companies are offering a plethora of long-term fixed price tariffs effectively tying consumers into a deal, typically between 1-4 years irrespective of the option to incur penalties (£30-£50[12]) to end such contracts. Longevity in energy supply contracts is perhaps a result of a wider trend developing across other sectors, annual gym memberships, mobile phone contracts over 24 months, soft furnishing deals spanning five years and long term car finance to name a few. These deals do not take into account forms household fluidity giving rise to changes in circumstance and household transition.

7.4 Limitations

During the research process I was faced with a range of challenges outside of my control. The following section outlines the limitations of my research and how I have dealt with the challenges presented.

7.4.1 Data metrics

As a result of data mining issues outside the control of the author and the wider CLNR team, substantial gaps emerged in the quantitative data related to metering metrics. The cause of these issues was due to equipment failure which ultimately meant only eight subsets of metering data was available for analysis and application in this thesis. Restricted sets of metrics data meant there was a lack of inferential statistics. A decision was taken to focus the quantitative analysis around descriptive statistics analysis on eight case studies where both qualitative data and quantitative data could be analysed. Although unfortunate, when qualitative data resulting from ethnographic interviewing is combined with quantitative metering metrics, the depth and insight the data provides in helping to understand the intricacies of electricity consumption is high. The eight households in my sample all illustrate some degree of 'fluidity', albeit some stronger than others.

7.4.2 Regional representativeness

Although the wider CLNR project covered two geographical areas: North East, Yorkshire and Humber, all the interviews presented as case studies in this thesis were undertaken in the Yorkshire and Humber region.

[12] www.uswitch.com

7.4.3 Analytical framework: Practice-based approach

The analytical framework used in this thesis is shaped by practice based approaches to domestic electricity consumption. Practice-based theory and its application to domestic electricity consumption in everyday life holds considerable promise, however there are some challenges related to this approach. Warde (2005) suggests in his review of practice theory, 'the argument remains to be made that theories of practice perform better than, or at least as well as, other approaches claiming similar merits, for example theories of culture and sub-culture or the theory or social worlds.' (Warde 2005:146). Furthermore, Shove (2010) points out that practice theory largely remains incompatible with current UK energy policy making practices, quoting Jackson's 2005 review, 'Our understanding of the dynamics of social practice is as yet so limited that it would be difficult to see how policy could make use of its position – beyond taking social norms a bit more seriously as influences on behaviour.' (Jackson 2005:55, Shove 2010b.)

7.5 Recommendations for future research

If I was going to conduct this research again, I would conduct interviews with energy suppliers and network planners to ascertain how they use social stratification to classify households. Having conducted limited reading around this issue, I understand they currently use social stratification models such as a classification of residential neighbourhoods (ACORN) or Experian's MOSAIC system which classifies the UK population into 15 main socio-economic groups and, within this, 67 different types. Further research is recommended to understand whether household fluidity can cause movement between these social groups. If indeed it does, fluidity may well expose a potential weakness in current policy development or direct marketing campaigns.

As discussed earlier, practical research is also recommended to understand how households on ToU or long term tariffs are implicated by periods of fluidity. In addition, further research on the causes and reactions to household fluidity is also needed. Socio-economic circumstances are often used as the driver behind this transitory phenomenon but I strongly believe fluidity carries implications not only for domestic energy policy but other key policy areas including health, social care, the ageing of the workforce and pensions, housing and transport. Fluidity may represent a new aspect of life course to which future generations should be prepared.

As a unit of study, the household is very much alive and I have found it a fascinating environment to conduct empirical research. This research provided me with a gateway into people's daily lives, each case study offered dimensions only in-depth research could uncover, and for that I feel privileged. Whilst my own research skills have been enhanced by this empirical research, I feel I have only scratched the surface. With the pace of new technological developments and consumer engagement with domestic energy efficiency on the increase there is substantial opportunity to explore the true implications of household fluidity on domestic energy supply and demand.

However, I remain realistic about the limitations of my research. All the interviews undertaken were with people of 'White British' origin. I appreciate this is a weakness in relation to ethnic diversity of the sample and presents a gap in helping to understand some of the cultural factors determining household dynamics, fluidity and energy behaviour. I have fed this concern back to the wider CLNR team and believe this weakness gives rise to considerable opportunity for further research in future. Other dimensions of fluidity should also be considered. In particular, further research on the interplay between 'rurality and fluidity' in shaping domestic energy demand. Basic reading around such interplay implies there are cultural differences between rural and inner-city families particularly in relation to social mobility which naturally carries implications for fluidity. Another dimension not explored in this research but uncovered during the wider CLNR programme was exploring the

implications of new born babies on domestic electricity consumption. The arrival of a new born baby also carries dramatic implications for domestic electricity consumption particularly in relation to rhythms and thresholds, gender roles, hubs and environments. Although this research has provided some insight into fluidity and its influence on domestic electricity consumption, I call upon domestic energy suppliers and network planners to actively engage with this concept as they continue to supply electricity and plan their networks for future generations.

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